

Dispute Resolution in the Space Age: Forensic Applications of Earth Observation Satellite Data Through Adaptation of Technical Standards Similar to DNA Fingerprinting Protocols

BRUCE S. MARKS*

TABLE OF CONTENTS

I. Satellite Remote Sensing Information Systems	22
A. Introduction	22
B. Promotion of Remote Sensing Technology in the U. S.	24
C. Outlook for the Future	26
II. Considerations in the Resolution of a Dispute	30
A. Traditional versus Nontraditional	30
B. Use of Scientific Evidence	31
C. Use of Neutral Expertise	32
III. Dispute Resolution and the Use of Technology	35
A. The Dispute	35
B. Potential Problems with Powerful Information Sys- tems	38
IV. References to Subject Matter or Process Specialists - Overview	39
A. Reference to Special Masters	40
B. Reference to Magistrates	41
C. Court Appointment of Neutral Experts	41
V. A Dispute Resolution Process Model Tailored to Facili- tate Application of Neutral Expertise	42
A. Available Authorities Support and Encourage the Development of Process Models	42
B. The General Process Model	44
1. Issue Identification	44
2. Expertise Identification	44
3. Proceedings	44
C. The General Model Applied to Complex, Relational Type Contract Disputes	45

* Attorney with the Denver law firm of Cornwell & Blakey. B.S., United States Air Force Academy; J.D. University of Virginia. Chairman, Special Comm. on Satellite Technology, ABA Section on Natural Resources, Energy, and Environmental Law.

VI.	Application of Remote Sensing Information for Technical or Evidentiary Support of Dispute Resolution	47
A.	Evidentiary Considerations Regarding Admissibility	47
1.	Expert Testimony	47
2.	Reliability of remote sensing techniques	47
(a)	Acceptance in the scientific community	48
(b)	Assignability to a scientific discipline	49
(c)	Nonlegal uses of a technique	49
(d)	Subjective interpretation	49
(e)	Uncontrolled variables	50
3.	Proper conduct of the remote sensing process	50
4.	Authentication and proof of contents	50
B.	Technical Standards and Protocols to Assure Admissibility - The DNA Fingerprinting Example	51
C.	Fertile Categories for Evidentiary Applications of Remote Sensing	54
VII.	A Conflict Management and Dispute Resolution Model Tailored for Application of Remote Sensing Information and Neutral Expertise - The Pacific Fisheries Problem as a Potential Case Study	59
VIII.	Conclusion	67
	Appendix Observational Programs for Global Data Acquisition	68
	Part 1: Representative Examples of Approved and Continuing Programs	68
	Part 2: Representative Examples of Proposed Future Programs	70
	Part 3: EOS Instruments: Initial Operational Configuration (IOC)	70
	Part 4: Earth Observation Missions (planned and approved) under consideration with the CEOS	73

INTRODUCTION

The wondrous advances of high technology have all but eclipsed our contemporary views of the value of "soft" or "social" science initiatives as an equally vital component of a healthy, well-balanced society. This Article, therefore, discusses dispute resolution within two important contexts. First, as a conceptual framework within which judicial and nonjudicial processes are rapidly evolving in response to increasing demands for timely and accurate conflict management. Second, the Article discusses some of the ways in which evolving dispute resolution theory and technique may synergistically interact with new technologies. In that re-

DISPUTE RESOLUTION IN THE SPACE AGE

gard, the Article focuses particularly upon certain advantages of increasing the use of neutral experts and nonadversarial techniques in both judicial and nonjudicial proceedings. In addition, the Article focuses upon ways in which the institutions of dispute resolution and the parties responsible for applying its discipline and guiding its mechanisms might contribute more readily to the economic health of the nation by more aggressively experimenting with and applying hard technology tools.

The premise is that all sectors of industry and government need to creatively and aggressively *apply* the very technologies which we have developed in order to improve efficiency and stimulate general economic growth. For that purpose, the author has chosen to examine two areas of advancing technology which have produced important, and in many ways strikingly similar, applications of technology not even anticipated at the time that society committed to advancing those technologies. The first area, now applied in both civil and criminal proceedings, is a technique known as "DNA fingerprinting" which is a spin-off application of the "micro" oriented studies of the human genome sometimes referred to as "gene mapping." The second area of technology is still evolving from the "macro" initiatives associated with earth sciences, known as earth observations technologies, or, in certain applications, as airborne and satellite remote sensing. The latter is a tool for mapping the habitat of the only life forms we know, the global ecosystem, while the former is a method for mapping the essence of life itself. Both activities are producing useful social science spin-offs, the utility of which seem to be limited only by our desire to integrate and apply them to any given challenge.

DNA fingerprinting has recently become a powerful evidentiary tool beyond its originally anticipated value to science.¹ Satellite and airborne remote sensing coupled with several related disciplines such as computer enhanced imaging and high speed data processing can, with proper planning and vision, become an immensely powerful informational and perhaps forensic tool. To that extent, the legal and judicial communities may benefit from this technology while also helping to stimulate more rapid but focused growth. These technologies have attributes which can and will contribute to improving our systems of social engineering and ordering particularly within the context of public administration and private governance of the nation's institutions and activities. The promise conceptually for the 21st century is that social science institutions can

1. The future of DNA fingerprinting as a courtroom tool is questionable at best as attacks on its validity continue with even greater fervor. "[C]ritics . . . say that there is no scientific consensus on how to do DNA testing properly; therefore, it is never admissible." Sherman, *DNA Tests Unravel?*, Nat'l L.J., Dec. 18, 1989, at 24, col. 1.

safely, effectively, and beneficially harness hard science tools for improved social ordering.

This Article thus examines recent developments in the admissibility and application of technical and scientific evidence. It also identifies evolving principles for developing technical protocols, which, along with evidentiary standards and procedures, are necessary to evaluate the relative advantages and disadvantages of the various types of dispute resolution formats - especially those applicable to technically oriented conflicts. It further addresses the advantages and risks of introducing critical expertise neutrally rather than adversarially. Finally, the Article assesses actual applications of DNA information in disputes and then compares that with and illustrates potential evidentiary applications for the information technology generally known as "remote sensing" which is rapidly becoming available as a tool for decisionmaking.

I. SATELLITE REMOTE SENSING INFORMATION SYSTEMS

A. *Introduction*

While this country has been a major leader in developing new technologies, we may lag seriously behind other countries in encouraging beneficial, innovative, and, above all, profitable applications of many of those technologies. By many, the United States is considered to be a "regulatory state" with its abundance of market-controlling laws and administrative agency regulations. The complexity of such regulation and bureaucracy impedes the growth and application of technology. Japan, on the other hand, is seen as a country which fosters the development and use of new scientific methods; hence, its rapid success in this area.

The lack of emphasis that the United States has placed on technology in recent years has affected all sectors of social ordering in the economy including the particular area of "corporate governance."² Satellite remote sensing is an example of a technology that, if encouraged and funded thirty years ago, might have prevented some complicated, inefficient, and expensive corporate disputes.

Satellite remote sensing of the earth is a technique for measuring the properties of the earth's land, ocean surface, and atmosphere from

2. See COUNCIL ON COMPETITIVENESS, PICKING UP THE PACE: THE COMMERCIAL CHALLENGE TO AMERICAN INNOVATION 32-36 (1988); COUNCIL ON COMPETITIVENESS, PICKING UP THE PACE: THE COMMERCIAL CHALLENGE TO AMERICAN INNOVATION 10-12 (1989).

DISPUTE RESOLUTION IN THE SPACE AGE

space.³ The sensors on the spacecraft collect electromagnetic radiation reflected from, or emitted by, the object under investigation. This collected radiation is used to determine the properties of the object. Ocean properties include sea surface temperature, wave height, current direction and speed, reflectance of substances in the water, and water depth. Atmospheric properties include temperatures and cloud cover, as a function of height, cloud movement and thickness, water vapor distribution, and the concentration of trace gases as a function of height. Properties of the land include vegetation type and health, mineral substances in the soil, geography, topography, water bodies, and urbanization.

A typical remote sensing satellite provides a platform for sensors and operational support equipment. Sensors are characterized by their spatial and spectral resolution. Spatial resolution is defined as the minimum detectible area on the surface of the object sensed, and is determined by examination of the number, location, and width of the spectral bands used for sensing. The spectral bands are selected to be sensitive to a particular substance of interest, such as chlorophyll for plant life, water for rivers or ice, and minerals for types of soil.

The communications system of the satellite provides a path for command and control signals from the ground to the satellite, and for the data from the satellite to the ground station. The ground station controls the satellite and is used to receive and preprocess the data. The data collection and interpretation entails: (1) collection and minimal processing of raw digital data at the ground stations to produce digital computer compatible tapes (CCT) and photographic image products, and (2) manipulation of the raw data by computer processing to extract particular types of information contained in one or more spectral bands, and integrating the remote sensing data with other data bases to produce analytical and predictive products.

Both the minimally processed or "nonenhanced" digital data, and the manipulated data or "value-added product" are sold in the market. Historically, nonenhanced data sales have constituted the bulk of the market sales. The fastest growing segment of this industry is the value-added product and service component, which consists of manufacturers of computer hardware and software for analyzing remote sensing data, and companies that interpret and integrate the data with other data bases to produce analytical and predictive products. The data collected by remote sensing satellites is used in such activities as mineral exploration, agri-

3. See DEP'T OF COMMERCE, SPACE COMMERCE, AN INDUSTRY ASSESSMENT 61 (1988). The principal author was Bruce D. Kraselsky. [hereinafter Kraselsky/D.O.C.]. Remote sensing is often restricted to methods that employ electromagnetic energy (light, heat and radio waves) as the means of detecting and measuring target characteristics.

culture, fishing, forestry, environmental monitoring, and land-use planning. The application of these techniques constitutes a rapidly expanding commercial enterprise. The United States, France, Japan, India, and the Soviet Union all have commercial remote sensing satellite systems in operation in addition to separate and distinct systems for national security purposes as well as others for civil governmental purposes, including science applications. The European Space Agency (ESA), Canada, Brazil, and China have also announced plans to launch such systems in the early 1990s.

Despite the usefulness of remote sensing data, obstacles exist which impede growth of a commercial sector in this area. These obstacles are especially prevalent in the United States, and generally consist of: (1) uncertain demand, (2) lack of reliable access to space, (3) high capital costs, and (4) long payback periods. Additional impediments arise in the institutional (law and policy) environment. These impediments include (1) the U.S. industry's inability to compete, on a commercial basis, against the offering of space goods and services at rates subsidized by the U.S. government and by foreign government-backed entities; (2) traditional government procurement practices that preclude companies from serving all customers (both national and international) from the same production lines; (3) industry's difficulty in gaining access, on commercially reasonable terms and conditions, to the necessary U.S. government facilities required for conducting space activities; and (4) no comprehensive and fully articulated national space policy coupled with a government commitment to long-term stability upon which U.S. industry can build its business plans and investment strategies.⁴

B. *Promotion of Remote Sensing Technology in the U.S.*

The U.S. land remote sensing satellite system, known as LANDSAT, began as an experimental program conducted by NASA. The system was declared operational in 1983 and turned over to the Commerce Department's National Oceanic and Atmospheric Administration (NOAA) as part of a Presidential Directive issued in 1979 that transferred the program to commercial operation by the private sector.⁵ This Directive was followed by the Land Remote Sensing Commercialization Act of

4. *Id.* at 68.

5. *Id.* at 67 (citing Presidential Directive NSC-54 (Nov. 16, 1979)).

DISPUTE RESOLUTION IN THE SPACE AGE

1984 (LANDSAT Act), which established the broad policy and financial requirements of the transfer.⁶

In addition to the transfer provisions, the LANDSAT Act authorizes the Department of Commerce, in consultation with other federal agencies, to license private remote sensing space systems that satisfy the provisions of the Act and are consistent with national security concerns and international obligations of the U.S. These obligations and concerns include making nonenhanced data available to all potential users on a non-discriminatory basis.⁷ The Department of Commerce has promulgated the regulations for licensing of private remote sensing space systems.⁸

The LANDSAT Act requires NASA to continue to enhance its research and development programs concerning remote sensing technologies, and to enter cooperative research and development arrangements with public and private sector research entities. As a complement to NASA's activities, the Department of Commerce is also required to conduct a continuing program of research and development in remote sensing applications for monitoring the earth and its environment, and for advancement of the technology for such monitoring. The Departments of Agriculture and Interior are also encouraged by the LANDSAT Act to conduct research and development programs in applications of remote sensing, including cooperative programs with the public or private sector.

On February 11, 1988, President Reagan issued a new directive on national space policy which includes commercial space initiatives.⁹ The

6. *Id.* (citing the Land Remote-Sensing Commercialization Act of 1984, 15 U.S.C. § 4201 (Supp. 1989)) [hereinafter LANDSAT Act].

7. "Nonenhanced digital data is most commonly sold in the form of computer compatible tapes" pursuant to a contract between the U.S. Department of Commerce and the Earth Observation Satellite Corp., contract No. NA-84-ESC-00125 (Sept. 27, 1985). *Id.* at 67. These contracts and their designators have recently been changed and updated.

8. *Id.* at 59 (citing Licensing of Private Remote-Sensing Space Systems, 15 C.F.R. § 960 (July 1989)).

9. See INTERNATIONAL INSTITUTE OF SPACE LAW, REAGAN'S FINAL SPACE POLICY (1988) (William Wirin, principal author).

Remote sensing by U. S. commercial endeavors was addressed in the new policy, stating, "encourage the development of commercial systems which image the Earth from space, competitive with or superior to, foreign operated civil commercial systems." *Id.* For example, LANDSAT produces images with 30 meter resolution. There was language in the authorizing statute giving the government the right to prohibit dissemination and publication of images which were objectionable from a national security perspective. This, however, was never a problem because 30 meter resolution lacks sufficient detail to provide significant sensitive information. French Spot Image images with 10 meter resolution became available in 1986 and pictures of the Chernobyl nuclear reactor site were widely published in newspapers and magazines. While the images gave some information, they did not reveal truly sensitive "national security" information. It was not until SOYUZHKART (U.S.S.R.) in 1987 marketed five meter resolution that the subject of MEDIASAT became a major topic of discussion. MEDIASAT is the concept of obtaining information for news stories by overhead satellite photography. *Id.* at 17. Through computer enhanced tech-

aspects of the Directive applicable to satellite remote sensing: (1) encourage the development of commercial systems which image the earth from space and are competitive with, or superior to, foreign-operated civil or commercial systems; (2) discuss remote sensing issues and activities with foreign governments that either operate or regulate the private operation of remote sensing systems; and (3) continue a research and development effort for future advanced remote sensing technologies.¹⁰

The Presidential Directive further delegates management of federal civil operational remote sensing to the Department of Commerce, and requires the Department to: (1) consolidate federal needs for civil operational remote sensing products so they can be met either by the private sector or the federal government, (2) identify needed civil operational (as opposed to pure science) systems research and development objectives, and (3) in coordination with other departments or agencies, provide for the regulation of private sector operational remote sensing space systems. The Directive also emphasizes the importance the Administration placed on private sector study of options for commercially useful follow-on systems for the LANDSAT program.

C. Outlook for the Future

Industry studies, which range from conservative to optimistic, predict that cumulative world-wide revenues from the nonenhanced data and value-added markets as a whole would be from 7.2 to 9.0 billion dollars for the 1987-1997 time frame.¹¹ This total translates from 0.7 to 1.5 billion dollars for nonenhanced data and from 6.5 to 7.5 billion dollars for value-added products and services. U.S. government purchases account for less than fifty-six percent of world-wide user demand, as com-

niques, five meter resolution images can be improved to approximately two meter resolution. This provides very significant detail and has potential uses for both media and intelligence gatherers, in addition to other commercial users. With these developments, the U. S.'s unstated policy of prohibiting U. S. entrepreneurs from providing images with greater than ten meter resolution was due to give way. Constraints on U. S. concerns would have proved fruitless as the media in the U. S., and others, could have purchased satellite images from foreign sources and legally imported them for use in the U. S. For all of these reasons, the 1978 secret directive signed by President Carter to limit civil satellites in the United States to 10 meter resolution was finally rescinded. *Id.* at 7 (citing N. Y. Times, Jan. 21, 1988, at 1). In the future, there will be a case-by-case review of commercial high resolution systems, with decisions based upon national security considerations presented at the time. National security will be considered during any review required by law, such as an application for a launch license under the Commercial Space Launch Act of 1984, Pub. L. No. 98-575, 98 Stat. 3055 (1984).

10. Kraselsky/D.O.C., *supra* note 3, at 69 (citing NOAA and NASA, *Space-based Remote Sensing of the Earth* (Sept. 1987) (a report to the Congress)).

11. *Id.* at 68.

DISPUTE RESOLUTION IN THE SPACE AGE

pared to roughly twenty-two percent each for U.S. commercial and foreign users. As world-wide demand continues to increase over the next twelve years, these percentages are expected to invert. Major U.S. government users are significant and include the Departments of Agriculture, Interior, and Defense, the Central Intelligence Agency, the Environmental Protection Agency, the U.S. Army Corps of Engineers, and the National Aeronautics and Space Administration. Uses include forest inventories, agricultural assessments, drainage and flood patterns, air quality, wildlife habitat evaluation, topography, environmental impact studies, sea conditions, and ocean pollution. Over seventy-five federal statutes require various types of monitoring that can be accomplished, in whole or in part, using satellite remote sensing.¹²

Major commercial users include oil and mineral exploration concerns, engineering and construction companies, agribusiness, forestry, ocean transport and fishing industries, land development, cartography, the research and academic community, and state and local governments. Industry studies indicate that U.S. commercial users will spend ten times more money on value-added services than for nonenhanced data at any given time during the 1987-1997 time frame.¹³

The development of Geographic Information Systems (GIS) is responsible for a growing portion of this demand. A GIS is the combination of remotely sensed data with other types of data, such as map, census, property ownership, and land use data, so as to produce a data base for useful and extensive commercial applications. More than twenty states have instituted resource information programs using computers and specialized software to merge remote sensing data with other data in broad-based geographic information systems.

The market for remote sensing data grows out of an existing group of users of nondigital aerial photographs.¹⁴ The ability to digitize information about the earth's resources and manipulate it to meet each user's particular information requirements, coupled with the continued decline in computer hardware and software prices, is expected to increase demand among the existing users as well as significantly expand the user market. The future growth of the industry is thought by many experts to be largely dependent upon educating the potential buyer because many

12. *Id.* at 69.

13. *Id.* at 62.

14. *Id.*; see also Onsrud & Dansby, *Geographic Information Systems and the Legal Community*, Feb. 1989 AM. CONG. ON SURV. & MAPPING BULL., at 30; Roitman, *Toward a Practical Policy on Public Access to Automated Mapping Data Bases*, 4 URISA PROCEEDINGS (1986); Epstein, *Legal Conflict Over Land Data and Information: A Basis for the Profession of Land Information Specialists*, 4 URISA PROCEEDINGS 197-203 (1986).

potential buyers do not yet know how to use the data nor do they appreciate its applicability in their industry.¹⁵

Obviously, the viability of a commercial U.S. remote sensing industry depends upon numerous factors, not the least of which is the strength and direction of national space policy and national industrial policy as a whole.¹⁶ For example, one factor which must soon be addressed is the growing problem of "space debris" which is threatening to obstruct access to some of the most useful orbital zones.¹⁷ A commercial investment in a given type of remote sensing satellite or other system will, at some point, become sensitive to the space debris issue because it bears upon the system's useful life.¹⁸ In addition, the authorities who may control access to orbit via licensing or other mechanisms,¹⁹ may, at some point, have to impose constraints on launch and satellite systems as a means of addressing the space debris issue. If those constraints are not commercially reasonable, they may become so onerous as to impair the ability of commercial or governmental operators to gain a sufficient toehold in the industry for economically sustainable development.

15. See Address by E. Donley, Space - The Next Competitive Arena, before the Space Station Commercial Users Workshop, in Nashville, Tenn. (Nov. 3, 1987) stating:

we need an agenda for the commercial success of space that joins our private and public sectors in a dynamic partnership. First and foremost, the company must have a sustainable, longer-term commitment for the space research program. This is particularly true for materials processing, and also true for such disciplines as *remote sensing and communications*. This commitment must span the senior management group and permeate to the depths of the organization. (emphasis added) (speech reprint on file with author).

16. Reynolds & Merges, *Toward an Industrial Policy for Outer Space: Problems and Prospects of the Commercial Launch Industry*, 29 JURIMETRICS J. 7 (1988); see also CENTER FOR STRATEGIC & INTERNATIONAL STUDIES, A MORE EFFECTIVE CIVIL SPACE PROGRAM 59 (1989); Glazer, *The Expanded Use of Space Act Authority to Accelerate Space Commercialization Through Advanced Joint Enterprises Between Federal and Non-federal Constituencies*, 12 RUTGERS COMPUTER & TECH. L.J. 339 (1987); Freeman & Inadomi, *Who's the Captain Kirk of this Enterprise?: Regulating Outer Space Industry Through Corporate Structures*, 18 U. C. DAVIS L. REV. 795 (1985); Cunningham, *Space Commerce and Secured Financing - New Frontiers for the U. C. C.*, 40 BUS. LAW. 803 (1985).

17. See INTERAGENCY GROUP (SPACE) FOR NATIONAL SECURITY COUNCIL, REPORT ON ORBITAL DEBRIS (Feb. 1989). With respect to space debris, a recent Presidential Directive provided that "all space sectors will seek to minimize the creation of space debris." INTERNATIONAL INSTITUTE OF SPACE LAW, *supra* note 9.

18. See INTERNATIONAL INSTITUTE OF SPACE LAW, *supra* note 9, at 7.

19. See OFFICE OF COMMERCIAL SPACE TRANSPORTATION, DEP'T OF TRANSPORTATION, HAZARD ANALYSIS OF COMMERCIAL SPACE TRANSPORTATION (1988); B. Marks, Space Debris - A Proposal for Handling the Industrial By-Products of Orbital Activity Based Upon an Integrated Analysis of Technical, Economic and Legal Aspects (July 12, 1989) (prepared for the American Institute of Aeronautics and Astronautics, Legal Aspects Committee, Space Debris Standards Combined Technical Subcommittee) (on file with the author); see also B. Kraselsky & B. Marks, Legal and Regulatory Proposals for Handling Orbital Debris (October 1989) (unpublished manuscript).

DISPUTE RESOLUTION IN THE SPACE AGE

For purposes of this Article, the limiting factor of primary interest is that of educating the user group(s) that are active in dispute resolution processes about beneficial ways to use remote sensing data. If it can be refined for use in resolving conflicts, whether in judicial or alternative forums, then more pervasive use of such data may in turn stimulate growth in remote sensing markets. It may also contribute to improvements in remote sensing technology itself insofar as legal and related applications are concerned. An additional and related near-term constraint is the ability to handle the projected extraordinarily high data rates and still derive commercially useful information. With the planned development and operation of advanced sensors and other imaging devices, data storage and analysis capabilities may remain in a relative state of infancy compared with the degree of sophistication and generating capacity of the in-space systems themselves. Therefore, in addition to major improvements in computing power,²⁰ there will also be an increased demand for onboard processors²¹ capable of removing bad or inadequate data before it is down-linked into the data transmission system. In those ways it may be possible to vastly increase the technical and economic efficiencies of future integrated space-based information systems. That deluge of available data should cause other subindustries to evolve, for example, one that focuses on the development of improved storage devices. Ultimately, the driving forces behind commercialization will depend upon the rate at which users consume the information so derived.

Image analysis does not usually involve complicated computations, but it does require that simple calculations be done on a very large number of points. Thus, without the improvement of microcomputer systems, the ability of any particular user to fit this particular kind of information source to the specific problem in need of solution will be constrained. It

20. See Kraselsky/D. O. C., *supra* note 3, at 70; see also Wolkomir, *As spacecraft pour out an ever-increasing flow of data, NASA scrambles to handle the flood*, AIR & SPACE, Oct. /Nov. 1989, at 79 (surveying NASA and non-NASA initiatives for data handling and analysis when the 1990's programs begin to yield their "deluge" of electronic information for which no handling system is yet planned or in place and also noting the rapidly deteriorating condition of 25 years worth of archived data, "less than 10% of which has been looked at" due to underfunded and unsupported data management and analysis programs).

21. See F. PEAT, *ARTIFICIAL INTELLIGENCE: HOW MACHINES THINK* (1988). Just as this Article was going to press, the Bush administration announced plans for a national fiber optic telecommunications system. Such a system could help provide the access, speed, and data analysis capabilities necessary to assure space and airborne data flow becomes timely, responsive, and operationally useful. See also Banks & Ison, *A new role for Freedom*, AEROSPACE AMERICA, Sept. 1989, at 30 (discussing the need for encouraging "operational remote sensing," noting it has different requirements than does scientific data gathering, and noting other obstacles, including those applicable to the Freedom Space Station).

should be noted, before continuing, that imaging and enhancement techniques are rapidly advancing in many other fields of inquiry aside from airborne or satellite based sensor applications. Forensic uses will undoubtedly ensue from those activities as well.²²

II. CONSIDERATIONS IN THE RESOLUTION OF A DISPUTE²³

A. *Traditional versus Nontraditional*

If, as some current commentaries suggest, the adjudicative process and its support systems in the United States is contributing materially to a reduced level of national productivity,²⁴ then more expedited, yet accurate, dispute resolution should be encouraged as a means for improving both public and private management or "governance." The public court system manifests this concern in the form of pressure to settle disputes, including efforts to annex arbitration and mediation processes into public adjudication²⁵ as well as direct party negotiations. The commercial sector has also begun to recognize a natural incentive to harness and streamline improved dispute resolution processes, motivated by an

22. See *supra* note 15; see also NTIA TELECOM 2000, U. S. DEP'T OF COMMERCE, CHARTING THE COURSE FOR A NEW CENTURY (1988) (stating "Today, a judicial regulatory bottleneck is affecting the wider and more effective distribution of information age benefits"); Marks & Cunningham, *Satellite Technology Committee Schedules Spring Workshop on RemoteSensing Techniques*, 18 NAT. RESOURCES L. NEWSL. 1, 3 (1987); DEP'T OF COMMUNICATION, OHIO STATE UNIVERSITY, A STUDY OF THE POLICY IMPLICATIONS OF THE DEVELOPING INTERNATIONAL MARKET FOR REMOTE-SENSING SATELLITE PRODUCTS AND SERVICES (1989) (R. Samaragiva and D. Nchia, principal authors).

23. Excerpted from article originally published as Marks, *ADR: Special Masters, Neutral Experts and Specialized Juries*, 18 COLO. LAW. 871 (1989).

24. See *supra* notes 15 and 16.

25. Federal legislation has been introduced to amend the Administrative Procedure Act to permit government agencies to use mediation and arbitration if both parties agree to its use. Cases in which precedent or important policy issues are at stake, however, would not be subject to the practice. Lavelle, *Congress Now Considering Dispute Resolution Measure*, Nat'l L.J., Feb. 5, 1990, at 22, col. 3. Efforts are also being made at the state level. The Colorado Dispute Resolution Act established a state-wide office of dispute resolution. That legislation, effective July 1, 1983, was codified at COLO. REV. STAT. § 13-22-301 (1973), and later amended by H. B. 1217, effective April 6, 1988; see also *Mediation Revisited: Amendments to the Colorado Dispute Resolution Act*, 17 COLO. LAW. 1297 (1988); Address of Chief Justice Joseph R. Quinn to the Colorado General Assembly, State of the Colorado Judiciary (Jan. 13, 1989) (discussing Colorado court programs and progress to date), *reprinted in part*, 18 COLO. LAW. 431 (1989); e. g., *Mitsubishi Motors Corp. v. Soler Chrysler Plymouth, Inc.*, 473 U.S. 614 (1985) (favoring contractual arbitration and advance provisions for mutually acceptable dispute resolution procedures). For a summary of state statutes relating to dispute resolution procedures, see AMERICAN BAR ASSOCIATION STANDING COMMITTEE ON DISPUTE RESOLUTION, STATE LEGISLATION ON DISPUTE RESOLUTION (1988).

DISPUTE RESOLUTION IN THE SPACE AGE

emerging appreciation for "avoided cost" or "externalizing cost" methodologies, among others, as tools for improving managerial efficiency and thus competitiveness.²⁶ This might represent the dawning of a new "conflict management" science triggering a far more pervasive level of alternative dispute resolution (ADR) which can be controlled and managed more effectively at the decision-maker's level. Heightened efforts to avoid conflicts or expedite their resolution may, however, contribute to an environment of wholesale discouragement of disputing as a legitimate means of ascertaining certainty. It is, therefore, a corollary to the central premise of this Article that disputing should be encouraged so long as it is coupled with efforts to improve the efficiency with which we may realistically dispose of more, rather than fewer, disputes.

The increasing popularity of ADR, both within public and private forums, highlights the stresses which our long-standing cultural reliance upon process places upon a "universally accessible" public court system.²⁷ Absent the kind of scientific fact which tends to allay uncertainty, deference has historically been accorded to legal analysis, advocacy, and persuasion. This deference to the application of legal "calculus," in the absence of the more empirical kind, has nurtured, in the Anglo-American system at least, a reliance upon "process" as the best available alternative to ultimately conclusive, scientifically verifiable and repeatable "fact." Thus, we rely upon the inherent strength of diverse checks and balances, in the form of distributed power, in the decision-making process, including that employed by the judicial branch of the government. The same has been less true, however, in the private sector where there has been an entirely different cultural base for acceptable norms of corporate, as opposed to public, administration; the former valuing secrecy and narrow lines of decision-making authority and the latter valuing more open and distributive methods.²⁸

B. *Use of Scientific Evidence*

Where risk and uncertainty are high, there has been an institutional preference for reliance upon the adversarial process, in combination with

26. See *supra* note 2.

27. See Address by Rex E. Lee, U. S. Solicitor General, *The American Courts as Public Goods: Who Should Pay the Cost of Litigation?* (Sept. 15, 1984), reprinted in 34 CATH. U.L. REV. 267 (1985). Lee infers there may be regressive taxation aspects to the equal cost of access to American courts because the size or value of the dispute is not factored into the access or disposition cost. Conversely, the American Arbitration Association assesses rates as a fraction of size/amount in controversy.

28. See generally M. Galanter & J. Rogers, *The Transformation of American Business Disputing* (1988) (unpublished manuscript on file with author).

distributive and collaborative processes. The "system," therefore, generally reflects a value judgment regarding how much process is justifiable in terms of time and cost in order to secure outcomes at or above some reasonable level of certainty. Where there has been a sufficiently high level of public interest in reliable dispositions, for example, in criminal justice and national security, science and technology have historically been employed, even at relatively high cost. As a result, forensic devices including fingerprints, lie detectors, radar guns, wire taps, sound and video recordings, voice fingerprints, and, more recently, computerized simulations, emulations, and enhancement, have all been harnessed to find the truth. The recent emergence and prominent use of forensic DNA fingerprinting²⁹ provides a particularly instructive analogy for illustrating the premise that science can supplant advocacy, at least to some beneficial, and thus, justifiable degree. Remote sensing technologies should follow suit.

In both the state and federal courts, there is substantial support and precedent for the innovative use of neutral experts. The introduction of incontrovertible "scientific" facts, where appropriate, tends to minimize the need to rely so exclusively upon the art and science of advocacy. Indeed, ever since Sherlock Holmes, Perry Mason, and others dramatized dispositive application of scientific or technical methods, the sleuthing aspects of the investigative phase of dispute resolution have long captured the imagination. Because controlled disputing is simply one of many processes by which we have learned to reconcile uncertainties or allocate risks, it is, and should continue to be viewed as, nothing more nor less than an integral part of the overall governance mechanism of Anglo-American business and social systems.

C. *Use of Neutral Expertise*

Complex disputes normally arise out of a tangled web of transactions and relationships assembled over a substantial span of time. Buried at the heart of most of these disputes is a body of specialized knowledge

29. See Marx, *DNA Fingerprinting Takes the Witness Stand*, SCIENCE, June 17, 1988, at 1616; M. SAKS & R. VAN DUIZEND, *THE USE OF SCIENTIFIC EVIDENCE IN LITIGATION* 99 (1983); e. g., *Spencer v. Commonwealth of Virginia* Nos. 881268, 881288 (Va. Sept. 22, 1989) (recently upholding rape and murder convictions based upon DNA evidence in two consolidated cases). Cf. *People of New York v. Castro*, No. 1508/87 (N. Y. Sup. Ct. Aug. 14, 1989) (The court ultimately found that DNA forensic identification tests to determine "inclusions and exclusions" are reliable and meet the *Frye* standard of admissibility. A pretrial hearing, however, should be conducted to determine if the experiments and calculations performed by the testing laboratory actually yielded results sufficiently reliable to be presented to the jury. See *infra* note 95.)

DISPUTE RESOLUTION IN THE SPACE AGE

that is often understood by only the parties involved. Thus, their specialized expertise is essential to a proper resolution of the problem. In a normal trial setting, each side marshals its own experts, meets at the courthouse, and engages one another, adversarially proclaiming only their side knows the truth. It is often easier and quicker to reach the middle ground by enlisting appropriate neutral experts, who are recognized by both sides as knowledgeable in the area forming the basis of the dispute.

The relatively informal tools of ADR³⁰ provide beneficial latitude in evidence admissibility, pretrial and trial advocacy, and the use of specialized expertise, tailored to the particular subject matter in dispute.³¹ The rules of evidence and civil procedure provide a framework for innovative molding of the experts' assigned role and objectives, including acting as an advisory or decisional jury.³² Governmental commissions or private associations may even be enlisted to provide the appropriate expertise.

30. Alternative Dispute Resolution (ADR) has arisen from what some have described as the "ADR movement" related to the dissatisfaction with conventional litigation. See, e. g., Lambros, *The Alternatives Movement: Rekindling America's Creative Spirit*, 1 OHIO ST. J. ON DIS. RES. 3 (1985). The movement essentially has two aspects; development and increased use of alternative processes for resolving disputes and the growth of widespread public support within the Bar, the business community, and the government for a new approach - a more deliberately costeffective approach to dispute resolution. See generally CPR LEGAL PROGRAM, AMERICAN BAR FOUNDATION, ADR AND THE COURTS: A MANUAL FOR JUDGES AND LAWYERS (E. S. Plapinger & E. S. Fine eds. 1987); J. LAPIN & R. PATTERSON, ALTERNATIVE DISPUTE RESOLUTION: NEW STRATEGIES FOR LITIGATION AND SETTLEMENT OF LEGAL CLAIMS ch. 6 (1989); D. Beerbower, Practical Aspects of Arbitration and Other ADR Methods in Natural Resources Disputes (rev. ed. 1989) (unpublished manuscript); B. Marks, Conflict Management and Alternative Dispute Resolution: Opportunities, Strategies and Techniques for an Environmentally Sound U. S. Energy Industry (1990) (unpublished manuscript); Marks & Martin, *Minerals Supply Contracts When the Market Goes South or North - Enforcement, Avoidance, and Renegotiation*, 32 ROCKY MTN. MIN. L. INST. § 5 (1986).

31. See *Symposium on Litigation Management*, 53 U. CHI. L. REV. 305 (1986); Brazil, *Special Masters in Complex Cases: Extending the Judiciary or Reshaping Adjudication?* 53 U. CHI. L. REV. 394 (1986); COUNCIL ON COMPETITIVENESS, PICKING UP THE PACE: THE COMMERCIAL CHALLENGE TO AMERICAN INNOVATION, *supra* note 2, at 32-36; see also 1 A. L. I. - A. B. A. RESOURCE MATERIALS, CIVIL PRACTICE OF LITIGATION IN FEDERAL AND STATE COURTS 138 (1985); COLO. R. CIV. P. Rule 81(a) (regarding water allocation disputes as special statutory proceedings and, therefore, an exception to COLO. R. CIV. P. 1); annotations to 28 U. S. C. A. § 636 (West Supp. 1988); MANUAL FOR COMPLEX LITIGATION 2d [hereinafter MCL2d] §§ 21. 5, 21. 54 (1985) (supplement to C. WRIGHT & A. MILLER, FEDERAL PRACTICE AND PROCEDURE (1969-1985)); Lambros, *The Summary Jury Trial and other Alternative Methods of Dispute Resolution*, 103 F. R. D. 462 (1984).

32. MCL2d, *supra* note 31, at § 21. 54. That section, entitled Other Referrals, states: Other special resources, such as referrals to a private or governmental technical body, use of an advisory jury of experts in a non-jury case, or consultation with a confidential "advisor" to the court, may be considered in complex litigation. . . . These comments are not intended to inhibit innovative uses of these recognized procedures, such as appointing a team of experts to serve under Fed. R. Evid. 706.

In addition to neutrality, expert consensus can, if achieved, contribute an additional benefit in the form of distributive decision-making much like the lay jury and the reviewing court, both integral parts of the present system.³³ Finally, neutral expertise can be safely employed without diluting the authority of the judiciary and without depriving parties of constitutionally guaranteed due process.³⁴ The same should hold true for voluntary nonjudicial proceedings. Accordingly, there is a growing interest in the applications of neutral expertise, distributive decision-making, and interest group consensus building in alternative dispute resolution.³⁵

33. See generally 1. W. HOLDSWORTH, A HISTORY OF ENGLISH LAW (A. Goodhart & H. Hanbury eds. 1956).

34. See Comment, *Boundaries of Article III: Delegation of Final Decision Making Authority to Magistrates*, 52 U. CHI. L. REV. 1032 (1985).

35. See Case Study Great Lakes Fisheries, *Dispute Resolution Forum*, published by National Institute for Dispute Resolution (April 1988). In that case, a federal district court judge in Michigan improvised a process under which the state of Michigan and various Indian tribes resolved disputes over how to manage and allocate treaty waters and related fishing rights once the Interior Department stopped regulating Great Lakes fishing. In 1979, the judge had ruled that an 1836 treaty between the tribes and the U. S. Government superceded the regulations of the state of Michigan for the treaty waters. Fishing competition had led to depletion of fish stocks, as well as violence among various tribal, commercial, and sport fishing competitors. Because the dispute involved a continuing relationship among the parties as well as a complex interrelationship of issues, compounded by a lack of legal standards or precedent, the judge concluded that an allocation plan should be developed by the parties with the assistance of a law professor appointed to act as the court's special master. In the course of facilitating this resolution process, the technical and scientific aspects of the case, including differing testimony by biologists, became some of the most dispositive evidence. Eventually, the parties jointly developed a computer model using five critical variables. They were then assisted by a neutral expert in computer modeling. The model scrutinized hypothetical solutions to verify whether their solutions met the parties' expectations and needs. The role of the computer was surprising and successful, at least insofar as resolving the biological issues. Eventually, the final negotiated plan created exclusive zones for sport, commercial, and tribal fishing. Additional zones were set aside for federal and state management to rehabilitate fish stocks. Finally, the state and federal governments allocated \$1. 5 million for a trust fund to assist the tribes in adjusting and, in some instances, relocating to new zones. The agreement is under implementation and the parties are jointly managing Michigan's Great Lakes fishery resources. This case illustrates the idea that advocacy can, to a great extent, be beneficially supplanted by scientific or technical inputs. A similar conflict today in the ocean fisheries industry presents a fertile opportunity for reverifying the experience of the Great Lakes fisheries case and for further advancing its techniques. In both cases public and private interests intermingled in a way which did not readily lend itself to the traditional adjudicative process. Furthermore, in the case of the ocean fisheries disputes, an additional technological tool, satellite imagery, may help to facilitate fact-finding in a manner hitherto unavailable, thus further supporting and enhancing the work of the neutral experts.

DISPUTE RESOLUTION IN THE SPACE AGE

III. DISPUTE RESOLUTION AND THE USE OF TECHNOLOGY

A. *The Dispute*

In protracted disputes there is typically present one or both of the following conditions:³⁶

1. A party (or parties) whose strategy is predicated upon a perception that the risk/benefits of delayed resolution outweigh the risk/detriments of immediate disposition.

2. A sufficiently complex, weighty, or expensive issue, interwoven with perceived uncertainties, justifying a highly incremental, if not unduly methodical, resolution process.

Conversely, most analyses which address how various resolution processes perform³⁷ caution that the participants must genuinely desire early closure and full disposition. This obvious conclusion is reminiscent of a contemporary riddle which goes: How many psychologists does it take to change a light bulb? Answer: only one; but the light bulb must want to change.

Modern commercial disputes, especially those that involve parties to long-term contracts, often arise by virtue of economic swings in the marketplace which create conditions different in degree and kind from those originally contemplated. In those instances, at least one party will undoubtedly see expedition of resolution as desirable while the other will prefer the opposite. In addition, it is likely that neither will want to compromise, given the likelihood that an eventual counter-economic cycle will reshift those conditions back again, even while the dispute resolution process is pending. Even mandatory arbitration, mediation, or other court-annexed alternative processes incorporated by statute commonly limit jurisdiction by the amount in dispute, subject matter, and other constraints, impeding the momentum for initiating and then concluding the dispute resolution process. Furthermore, commercial actors are frequently reluctant to enter into contracts which specify binding forms of dispute resolution if they might thereby give up the latitude to insist upon litigation and then find later that it would have been tactically ad-

36. R. FISHER & W. URY, *GETTING TO YES* 17-98 (1983).

37. See Marks & Martin, *supra* note 30; ADR AND THE COURTS, *supra* note 30, at 212-13; see also Note, *Deregulation and Natural Gas Purchase Contracts: Examination Through Neoclassical and Relational Contract Theories*, 25 WASHBURN L.J. 43, 53 (1985) (asserting that "in classical contract theory, the exchange, by hypothesis, is able to be fully structured at the outset through the process of bargain. This collapsing of all the events of the future into the present is known as *presentiation*. . .") (emphasis added); I. MACNEIL, *THE NEW SOCIAL CONTRACT: AN INQUIRY INTO MODERN CONTRACTUAL RELATIONS* (1980).

vantageous.³⁸ Therefore, absent voluntary contractual agreements in advance, at least one party, the "hold-out," often tends to resist expeditious resolution, presumptively, of course, in good faith.³⁹ As a result, "getting to yes"⁴⁰ is impossible where initially getting the process itself underway and expeditiously concluded is so difficult.

Accordingly, the pertinent issue today is not which method of ultimate resolution is most appropriate, but rather whether establishing incentives for early disposition by *assured initiation* of expeditious proceedings is preferable, and if so, how improved uses of technology, combined with efficient processes, could contribute to that goal.⁴¹ The issue can be stated with equal persuasion as whether hard science can be beneficially applied *and* effectively controlled with existing conflict management and disposition methods in either the primary or alternate dispute resolution system.

Where disputes arise out of or lend themselves to technical development of "incontrovertible" facts, the inevitable "hold out" problem may be avoidable, perhaps even via early summary process. Application of such solutions, however, can create a new dilemma where one person's incontrovertible fact may be another's speculation or opinion, thus simply transferring the adversariality to the "experts." One promising approach to circumventing the transference problem is the broader and more innovative use of *neutral* expertise including knowledgeable advisors, panels, and juries engaged by the decision-maker(s).⁴² When this process is carefully combined with sufficiently verifiable technical information, disputing parties, with or without formal court intervention, may

38. Cf. *supra* notes 30-35 and accompanying text.

39. See Note, *Tort Remedies for Breach of Contracts: The Expansion of Tortious Breach of the Implied Covenant of Good Faith and Fair Dealing into the Commercial Realm*, 86 COLUM. L. REV. 377 (1986). The phrase "bounded rationality" was coined by Professor Simon to describe human decision-making constraints that arise from inherent limitations on time, attention, and comprehensional capacity. See H. SIMON, *MODELS OF MAN* (1957); Simon, *Rationality as Process and as Product of Thought*, 1978 AM. ECON. PAPER & PROC. 1.

40. R. FISHER & W. URY, *supra* note 36.

41. See CENTER FOR PUBLIC RESOURCES, INC., CORPORATE POLICY STATEMENT ON ALTERNATIVES TO LITIGATION. The increased use of corporate policy statements favoring ADR may remove the risk of perceived weakness associated with a disputant suggesting that ADR be used prior to litigation. This social science approach to a managerial, rather than legal, method to resolve disputes is a step in the right direction.

42. MCL 2d, *supra* note 31, at §§ 20. 14, 21. 5. The additional cost of a neutral expert may often be avoided if the matter can be referred to a master under Rule 53 or to a magistrate. Generally such referrals are more likely to shorten a trial, while the objective of an appointment of a neutral expert is to achieve a more understandable trial. See also Rothstein, *The Collision Between New Discovery Amendments and Expert Testimony Rules*, 14 LITIGATION 17 (1988); Wessel, *Adversary Science and the Adversary Scientist: Threats to Responsible Dispute Resolution*, 28 JURIMETRICS J. 379 (1988).

DISPUTE RESOLUTION IN THE SPACE AGE

be inclined to make better and more pervasive use of such information. In an optimum application, the information itself will obviate the need for additional process scrutiny, perhaps facilitating early, informal intervention and disposition.⁴³ There are substantial indications that the commercial sector is culturally biased against disputing as a productive means for achieving and enhancing outcomes;⁴⁴ in other words, disputing is discouraged even where no adequate substitute may be available, due to its perceived tendency to create counter-productive entanglements. This bias may be more characteristic of privately owned and managed organizations where secrecy and minimal dilution of authority are highly valued. Therefore, commercially significant issues fester or are even suppressed only to reappear later in different and frequently more virulent forms. This is particularly true in complex, relational contexts⁴⁵ when responsible managers or executives have not been given a commensurate level of authority to deal with the "presentation"⁴⁶ aspects of their role. Even where a manager may have sufficient authority, it may be difficult to appreciate the need and urgency for its application in a given circumstance. For example, in contractual disputes, supervening inequality may lead the parties to eventually "renegotiate" out of a disadvantageous impasse, often by inaction or default, only to find out years later that they had inadvertently laid the foundation for different or even bigger problems. (For example gas and coal supply contract disputes and other similar long-term or relational based conflicts.⁴⁷) These observations seem to hold true for extrinsic as well as intrinsic conflicts, both of which directly affect organizational efficiencies.⁴⁸

Complex, relational disputes, triggered by apparently incomprehensible forces, are good examples of fertile ground for the use of *subject matter experts* in the resolution process. But dispute avoidance via early comprehension of "triggering facts" may be an even worthier systemic goal. In that regard, combining neutral experts with powerful expert systems may provide a superior tool in the type of dispute representing large, complex, relational dislocations. On the other hand, technologically powerful information systems such as those available in remote sensing devices, might contribute immensely to private/public ordering

43. M. WESSEL, *THE RULE OF REASON: A NEW APPROACH TO CORPORATE LITIGATION* (1976). See also Wessel, *Alternative Dispute Resolution for the Socio-Scientific Dispute*, 1 J. OF L. & TECH. 1 (1986).

44. See generally M. WESSEL, *supra* note 43; Wessel, *supra* note 43; see also M. Galanter & J. Rogers, *supra* note 28.

45. See generally H. SIMON, *supra* note 39; Simon, *supra* note 39.

46. See I. MACNEIL, *supra* note 37, at 60.

47. See Marks & Martin, *supra* note 24.

48. See M. Galanter & J. Rogers, *supra* note 28.

in such arenas as waste disposal siting controversies, industrial planning, compliance and enforcement, traffic management, transportation system planning and management, land use, zoning and development, construction, traffic accident investigation and disposition of associated liabilities, contraband control, tax assessments, disaster preparedness and liability, and numerous types of anticompetitive activity.

B. *Potential Problems with Powerful Information Systems*

The effectiveness of powerful information systems will be a direct function of its pervasiveness, which in turn will be determined by its permissible invasiveness. Therefore, as in the debates concerning nuclear security (energy versus weaponry), informational power will threaten traditional balances between public necessity and private security as well as between private opportunity and sovereign secrecy. Likewise, just as nuclear nonproliferation has become a "nonreality," policies of suppression of publicly and privately controlled information are also likely to fail. Therefore, harnessing the benefits while controlling the potential harm, of such information must be the goal.

Perhaps that goal is achievable via enforced neutrality in the active use and management of the information commodity itself. Either a safe, acceptable national repository must be available, from which withdrawals of pertinent information can be managed pursuant to a reasonable, balanced process or it must simply be allowed to proliferate in the free marketplace of ideas. If the former, or some combination of the two extremes, prevails then the repository *and* process must, arguably, be born of dispute resolution science.⁴⁹ If the information is to properly serve both public and private decision-making through judicious access to, and application of, higher powered information, continuous and expeditious balancing of interests is critical.⁵⁰

Maintaining the difficult balance between encouraging diverse positions on the one hand, and earlier compromise and consensus on the other, could be substantially enhanced by increased utilization of nonadversarial methods, especially when coupled with forwardlooking adaptation of technological support. To that end, more frequent use of technical and scientific methods to supplant conjecture and advocacy could help to reduce adversariality to a minimum, focus it more productively where it *is* needed, and optimize efficient and effective resolution efforts.

49. See generally M. WESSEL, *supra* note 43; Wessel, *supra* note 43.

50. See *supra* text accompanying note 24.

DISPUTE RESOLUTION IN THE SPACE AGE

IV. REFERENCES TO SUBJECT MATTER OR PROCESS SPECIALISTS - OVERVIEW

Parties or judges, proceeding pursuant to judicial Orders of Reference may employ directly masters, magistrates, neutral experts, panels, and juries. The primary authorities for such references are Fed. R. Civ. P. 53,⁵¹ Fed. R. Evid. 706⁵² and 28 U.S.C. s. 636.⁵³ The *Manual for Complex Litigation* (hereinafter MCL) collects the authorities and cites the current statutory and regulatory provisions and history and discusses their essential pros and cons.⁵⁴ It defines "complex litigation," noting, in part, that cases which represent unusual problems require extraordinary treatment. It also identifies classes of potentially complex cases⁵⁵ that require special handling techniques. Complex multiparty resource allocation disputes clearly are complex cases. The pertinent federal and state laws are largely identical and support wider utilization of ADR, including reference procedures.⁵⁶

Many courts agree and have ruled in favor of wider use of special handling techniques so long as the case is "exceptional."⁵⁷ While this trend raises potentially serious issues pertaining to judicial authority and due process, it also encourages judicial management through wider application of expertise.⁵⁸

51. MCL2d, *supra* note 31, at §§ 21. 5, 21. 52; *see also* D. EPSTEIN, G. GROTHEER, R. SIEGEL, J. GRIEDER, H. BARLOW, & E. HOFFMAN, 4 FEDERAL LITIGATION GUIDE ¶ 50. 04 (1988); J. MOORE, J. LUCAS, & K. SINCLAIR, MOORE'S FEDERAL PRACTICE ¶ 53. 05[2] (2d ed. 1989).

52. 11 J. MOORE & H. BENDIX, MOORE'S FEDERAL PRACTICE, 706. 01[3. -1] (2d ed. 1989); *see also* Colorado Rules of Evidence (annotated), Jacobson & Bukholtz (3d ed. 1988), at 706-1-3 *General Comment(s)*; and, *Practice Comment*: noting that Rule 706 should be invoked a reasonable time prior to trial; MCL 2d, *supra* note 31, at § 21. 51.

53. J. MOORE, J. LUCAS, & K. SINCLAIR, 7-Pt. 2 MOORE'S FEDERAL PRACTICE ¶ 73. 02[3. -4] (2d ed. 1989), stating, "the statutory grant of authority for the magistrate to conduct all civil proceedings in a case referred on a consensual basis under § 636(c) 'includes the power to conduct jury and non-jury trials and *decide dispositive motions*.'" (emphasis in original).

54. MCL 2d, *supra* note 31, at § 0. 10.

55. MCL 2d, *supra* note 31, at § 0. 22, noting "[c]ases requiring special treatment in accordance with the procedures in this Manual."

56. MCL 2d, *supra* note 31, at § 23. 12.

57. *See infra* note 64 and accompanying text.

58. FED. R. CIV. P. 16(c)(7) enumerates "the possibilit[ies] of . . . the use of extrajudicial procedures to resolve the dispute" as matters for consideration and action at pretrial conferences. *See also* Booms, *The New C. R. C. P. Rule 16 - Taking the Pulse*, 13 THE DOCKET 9 (1989).

A. Reference to Special Masters

Fed. R. Civ. P. 53 (a) provides for appointment of masters, including referees, auditors, and examiners. Rule 53(b) provides that such references shall be the exception and not the rule.⁵⁹ However, the MCL notes a broader rationale for referrals to masters:

Notwithstanding this general admonition, however, referral to a magistrate or master may be useful in some situations. For example, referral may be appropriate . . . if, due to the unusual magnitude of the supervision needed in the complex case, failure to make referral would result in inattention or undue delay. Continuing supervision and timely rulings are ordinarily more important than personal supervision by the judge.⁶⁰

Courts have recently begun to appoint special masters in complex cases without strict limitation as to whether those cases are exceptional. Often, the cases involve corporations and the masters are used explicitly for the purpose of facilitating settlement. Where the court believes a jury of laymen is incapable of dealing unaided with complex or confidential issues, it is then desirable to enlist the aid of a master, whose findings upon the issues submitted to them are admissible as evidence of the matters found and may be read to the jury.⁶¹ As an efficient allocation of resources, masters are particularly appropriate in the implementation of complex, equitable decrees which require ongoing judicial supervision. The latter point is well taken where fashioning an acceptable interim operating order or other form of equitable decree in a natural resource or similar allocation conflict would facilitate both final disposition of past issues and initial disengagement of the litigants so they might sooner focus upon present and future issues.

Rule 53(e)(3), relating to jury actions, provides that the master shall not be directed to report the findings because they are admissible as evidence and may be read to the jury. Any reference to a master which delegates the court's decision making powers may be an unconstitutional delegation of duties and responsibilities. However, a master acting under Rule 53, is regarded more as a court appointed expert.⁶² Thus, it appears to be improper for a trial judge to designate a master as the ultimate

59. See cases collected at annotations to 28 U. S. C. A. § 636 (Supp. 1989), especially n. 7, to the effect that such delegations do not violate article III so long as the ultimate decision is made by the district court.

60. MCL 2d, *supra* note 31, at § 20. 14. In jury trials, there must be a showing that the issue is "complicated" to justify a reference. The master's findings are admissible as evidence and may be read to the jury subject to rulings by the court on legal issues, but are not binding on the jury. COLO. R. CIV. P. 53(e)(3). The master's report in bench trials is binding on the court unless clearly erroneous. COLO. R. CIV. P. 53(e)(2).

61. See MCL 2d, *supra* note 31, at §§ 20. 14, 21.5.

62. See MCL 2d, *supra* note 31, at § 21.52.

DISPUTE RESOLUTION IN THE SPACE AGE

arbiter of fact *and* law. However, where a master works as or with an expert there is still substantial room for innovation and improved efficiency.⁶³

B. *Reference to Magistrates*

Federal district court judges are empowered by statute to refer nondispositive pretrial matters to a magistrate for determination, and dispositive pretrial matters for evidentiary hearings and submission of proposed findings of fact and conclusions of law.⁶⁴ Where the reference is pursuant to the statute, the limitations otherwise imposed by Rule 53 are presumed inapplicable, unless the order expressly provides to the contrary. The real value of magistrates lies in their ability to handle pretrial matters.⁶⁵ The statutory grant of authority for the magistrate to conduct *all* civil proceedings in a case referred on a *consensual* basis includes the power to conduct jury and nonjury trials and decide dispositive motions. Delegations to magistrates do not necessarily violate the Article III authority of the federal courts, and the scope of the magistrate's authority may include the unilateral empaneling of a jury to render a general verdict resolving all factual issues. While that does not seem to confer the specific authority to conduct a jury trial, unless so agreed in the Order of Reference, magistrates may conduct special statutory proceedings, on a broad range of matters, without the necessity of showing exceptional circumstances.⁶⁶ Therefore, a magistrate, like a master, has ample room for innovation, including employing neutral experts, individually or in groups.

C. *Court Appointment of Neutral Experts*

Fed. R. Evid. 706(a) specifically provides:

The court may on its own motion or on the motion of any party enter an order to show cause why expert witnesses should not be appointed and may request the parties to submit nominations. The court may appoint any expert witnesses agreed upon by the parties, and may appoint expert witnesses of its own selection.

63. The decision to seek court-appointed experts is a matter of trial tactics.

64. 28 U. S. C. §§ 636(b)(1)(B), 636(c).

65. See MCL 2d, *supra* note 31, at § 21.53; see also Comment, *supra* note 34, at 1043-44.

66. Indeed, a magistrate may conduct proceedings in a jury or nonjury civil matter and order the entry of judgment in the case if specially authorized by the court to exercise such jurisdiction. MCL 2d, *supra* note 31, at §§ 21.53, 21.54.

Use of court-appointed experts is not a radical departure from the traditional adversary model of litigation and, in appropriate cases, should be considered by the judge, even if not requested by the parties.⁶⁷

Neutral experts in complex, technically oriented, or scientifically-based disputes may act as facilitators or adjuncts to the lead neutral expert.⁶⁸ Rule 706 thus encourages and supports referrals to private or governmental technical bodies, use of expert advisory juries, and consultation with confidential advisors so long as used to make the system more effective and not to displace the parties' right to resolution through a trial.⁶⁹

V. A DISPUTE RESOLUTION PROCESS MODEL TAILORED TO FACILITATE APPLICATION OF NEUTRAL EXPERTISE

A. *Available Authorities Support and Encourage the Development of Process Models*

When experts proceed as juries their distributed authority may be judicially supervised using established procedures for fair selection, such as preemptory challenges and *voir dire*.⁷⁰ The ability to assess an expert panel's postdecision rationale, by polling, can also provide valuable information, especially for long-term relational disputants, in planning, negotiations, and subsequent dispute avoidance.

The MCL cites, as an example, an administrative agency process known as the Colorado Joint Review Process (JRP), which is applicable to preproduction natural resource disputes.⁷¹ The JRP is actually a state agency specifically created to find and fit appropriate processes to the

67. MCL2d, *supra* note 31, at § 21.51. The inherent power of a trial judge to appoint an expert of his own choosing is virtually unquestioned. FED. R. CIV. P. 706 advisory committee note.

68. Dauer & Nyhart, *An ADR Procedure for Liability Allocation and a Joint Defense Agreement*, 2 ALTERNATIVES TO THE HIGH COST OF LITIGATION, Dec. 1984, at 14.

69. See Freedman & Prigoff, *Confidentiality in Mediation: The Need for Protection*, 2 OHIO ST. J. ON DIS. RES. 37 (1986). In most such cases, the neutral expert agrees in advance to the general rules of confidentiality which will effectively bind him or her and all the parties. In addition, the neutral's opinion is seldom put in writing. Thus there is no document subject to later discovery by a nonparty to the ADR.

70. As to further attributes of experts acting in panels, see McGovern, *Court-Appointed Experts and Zampano, Settlement Conferences with Experts in ADR AND THE COURTS*, *supra* note 30, at 245.

71. Colorado's Joint Review Process [hereinafter JRP] for Major Energy and Mineral Resource Development projects, Colorado Department of Natural Resources, December, 1980 codified at COLO. REV. STAT. § 34-1-101; Colorado's Administrative Organization Act of 1968 codified the Colorado JRP originally pursuant to COLO. REV. STAT. § 24-1-124(2.1)(b) (1968). The Colorado JRP thus became an "agency [which] shall exercise its

DISPUTE RESOLUTION IN THE SPACE AGE

particular subject matter disputes typically encountered at the permit issuance stage. The JRP is designed to be flexible and broadly adaptable. It could probably be modified to address numerous other kinds of industrial projects because its value lies in its ability to successfully resolve intergovernmental conflicts which are also interdisciplinary and likely to impact public as well as private interests. Its legislative declaration states:

The General Assembly hereby finds, determines and declares that the continued beneficial development of its natural resources is important to the State of Colorado; that the governmental permits and licenses to be obtained by a natural resources developer can cause confusion and delay . . . The General Assembly further declares that the Colorado Joint Review Process shall be the proper agency of state government to undertake the coordination function so the problems arising in the *preproduction* stages of natural resources development projects can be expeditiously resolved.⁷²

Once production begins, however, disputes might still be avoided or resolved by a similar judicial process, within which courts would enlist administrative agencies such as the state oil and gas conservation commission to act under a process similar to the JRP, pursuant to an Order of Reference.⁷³ Such a judicial process does not now exist. Similarly no uniform arbitral process has been devised, only *ad hoc* approximations at best. Thus, state and federal courts, assisted by litigants and their counsel, might contribute significantly by creatively employing neutral expertise pursuant to such a model.⁷⁴

Where formal procedure and evidentiary entanglements potentially inhibit direct judicial utilization of such a model, then alternative forums may become the appropriate testing ground for "operational evaluation," if not the exclusive locale for regular and frequent application.⁷⁵ Just as remote sensing is now in need of operational, as opposed to scientific application and refinement, so too are "operational" dispute resolution systems.

powers, duties, and functions as prescribed by law within the department of natural resources. . . ."

72. COLO. REV. STAT. § 34-10-102 (1973).

73. The JRP, applied to AMAX, Inc.'s Mount Emmons mining project, is an example of a large-scale negotiated environmental mediation. The mediation involved the creation of a voluntary inter- and intragovernmental process to coordinate the environmental and land use decision making process among federal, state, and local levels of government.

74. J. Bowman, *Arbitration of the Gas Contract Dispute: An Alternative to Litigation*, (Oct. 11-12, 1988) (unpublished manuscript); see, e. g., *Mitsubishi Motors Corp. v. Soler Chrysler-Plymouth, Inc.*, 473 U.S. 614 (1985) (favoring arbitration and advance provision for mutually acceptable dispute resolution procedures.)

75. See Quinn, *supra* note 25, at 431 (noting that substantial progress has been made in developing dispute resolution programs but also cautioning that a lack of resources may impair further progress toward the legislature's ultimate goals.)

B. *The General Process Model*

1. *Issue Identification.* The parties, with the help of their attorneys, staff, and experts, would assemble their most comprehensive "maximum" issue list. This list would be assembled prior to conducting any discovery and would differentiate factual, technical, and legal issues. The maximum list would also establish the party's preferred issue priorities, sequence for resolution, rationale, and expected outcome. The maximum lists would be submitted, in confidence, to a magistrate or master, working with appropriate advisory experts. That master-expert team would evaluate the overall issues and decide relative priorities, probable sequence of disposition, and likely outcome. This phase would culminate in the neutral team's assembly of its proposed composite "minimum" list within a specified time frame.

The composite minimum-maximum or "mini-max" list would constitute a proposed Statement of Issues, annotated with the proposed method and sequence of resolution, assigned time frames for completion of its phases, and final disposition. That blueprint, or "protocol," would be further annotated with supporting rationale and become a record upon which the parties could append their contentions for subsequent argument and review.

2. *Expertise Identification.* As the mini-max process proceeds, the master-expert team(s) would also identify any additional expertise needed for independent research investigation, derived after first assessing the information likely to be available in discovery. This approach would tend to assure that the parties have a financial incentive to produce information in discovery or risk being penalized if their reluctance to stipulate to or produce potentially dispositive information created the need for neutral evaluation or verification. It would also help structure and expedite subsequent discovery.

3. *Proceedings.* The necessary specialists would build their analyses pursuant to the protocol. They would submit their findings or recommendations to the expert team for assembly of the component parts and then propose a disposition report. The parties would have the opportunity to propose changes and argue or preserve any contentions for hearing and subsequent appeal. The judge could either order further proceedings or propose a final order, upon which the parties could move, if desired, for a trial as to any or all parts. A contesting party who did not prevail at trial might be assessed fees and costs; similarly, failure to accept a settlement which subsequently proved better than the trial result could also trigger penalties.

DISPUTE RESOLUTION IN THE SPACE AGE

C. *The General Model Applied to Complex, Relational Type Contract Disputes*

Gas contract disputes are one example of commercial sector conflicts which arise within a highly interconnected web of technical, economic, regulatory, contractual, political, and historical considerations which have made gas marketing and contracting practices highly market sensitive.⁷⁶ The upstream and downstream segments of the industry meet at the juncture represented by producer-pipeline purchase of supply contracts, which connect the segments of the industry via its commodity transmission system, moving a physical energy source from its point of origin to its point of application.⁷⁷ That system therefore works like the drive train of an automobile, transferring the engine's power output to the wheels where the actual driving force is applied to the road. In this analogy, the gas contract works like a clutch, providing a means for smoothly engaging and disengaging the upstream and downstream segments of the system. The demands on a mechanical clutch can be anticipated within certain design parameters. The price and volumetric demands on a gas supply system, however, are unpredictable and uncertain. When these contracts exhibit market insensitivity, conflicts arise and act upon the underlying relationship, often causing it, like a clutch, to lose adjustment, suffer wear and tear, or even break down. Most importantly, unlike a mechanical clutch, repair or overhaul of the gas contract must be performed while the system is running! Therefore, a dynamic repair technique is required to allow continued operation while avoiding system breakdown.

Negotiated settlements provide only marginally adequate dynamic repairs but have at least illustrated the two primary requirements for successful disposition: resolution of past take-or-pay liabilities⁷⁸ and renegotiation of the business relationship for the future. The first issue often

76. Since *Transcontinental Gas Pipe Line Corp. v. State Oil & Gas Bd. of Mississippi*, 474 U.S. 409 (1986), this category of litigation has grown at a rate greater than that at which such cases are being judicially resolved. The Colorado Oil and Gas Conservation Commission is expressly required to dispose of issues in a manner consistent with the federal scheme, COLO. REV. STAT. §§ 34-60-102, 106(5), (8) (1973). The *Transcontinental* case may be read to imply that so long as the federal judiciary is the ultimate decision-maker with respect to such "contract" disputes, federally supervised disposition would likely pass muster in the Supreme Court.

77. The point of conversion is from potential to kinetic energy, usually as combustion heating for home or industrial applications. See also Lemay, *Settling Natural Gas Contract Disputes: The Pipeline Perspective*, 3 NAT. RESOURCES & ENV'T 7 (1989); Lowe, *Gas Contracting: The Lessons of the Seventies*, 3 NAT. RESOURCES & ENV'T 3 (1989); Strohl, *Settling the Take-or-Pay Claim: The Producer's Perspective*, 3 Nat. Resources & Env't 11 (1989).

78. Strohl, *supra* note 77, at 11.

revolves around how to structure settlement of those liabilities, whether a cash payment, a "reservation fee" for future gas purchases, or an investment. The second issue revolves around developing a market sensitive contract for future sales (an adequately rebuilt or redesigned clutch).

Factual and technical subissues frequently raised in the course of resolving the two key issues include:

(1) For pipeline companies, securing continuing supplies of gas, retaining flexibility between purchase commitments and market demand, eliminating accrued take-or-pay liability, and avoiding cash settlements while maximizing the ability to pass costs through to customers. These considerations are driven by prudent concerns associated with all relationships downstream of the contract.⁷⁹

(2) For producers, the upstream considerations are paramount and include maintaining cash flow by enforcing take-or-pay claims, increasing the long-term present value of reserves, meeting commitments and obligations to royalty owners, maintaining the life of leases which may revert to lessors, and protecting against drainage of reserves by producing wells on other leases.

In addition to requiring the right array of experts who comprehend these market and technical subissues, third party and public interests must often be factored into the resolution. Difficult legal issues may include affirmative defenses such as *force majeure*, among others.⁸⁰ Techniques used for gas contract dispute avoidance and resolution to date have been tantamount to jamming a screwdriver into a spinning clutch, poking here and jabbing there, in an attempt to fix the clutch without stopping and overhauling it.

A more sophisticated dynamic repair mechanism would combine the state's department of natural resources or its oil and gas conservation commission pursuant to a JRP-type of process. The commission's director, commission members, or its retirees could function in the master-expert team role pursuant to judicial supervision. Similar mechanisms might benefit conflict management and dispute resolution in other categories as well.

79. LeMay, *supra* note 77, at 7.

80. Commercial impracticability or similar market failure related defenses, including those provided by the Uniform Commercial Code, the common law, and those arguably arising pursuant to unforeseeable governmental actions. For a brief summary of contract clause "fixes," previously attempted, and how the FERC's well-intentioned restructuring of the gas industry may have exacerbated the problem over the past 20 years, see Lowe, *supra* note 89.

DISPUTE RESOLUTION IN THE SPACE AGE

VI. APPLICATION OF REMOTE SENSING INFORMATION FOR TECHNICAL OR EVIDENTIARY SUPPORT OF DISPUTE RESOLUTION

A. *Evidentiary Considerations Regarding Admissibility*⁸¹

When remote sensing information has been introduced in litigation it has usually been used to accomplish one or more of three compatible functions: (1) to document conditions over a large or inaccessible geographical area, (2) to document transient or intermittent conditions, and (3) to provide a visual representation of conditions primarily documented by more conventional types of evidence.⁸² The most salient issue in submitting evidence in court, of course, is its admissibility. The admissibility is based on a combination of judicial and technical standards. Not surprisingly, the submission strategy for remote sensing evidence must parallel that employed for most other types of scientific evidence. The following factors are relevant to determining admissibility:

1. *Expert testimony.* The testimony of an expert witness is essential for the successful admission of remote sensing information. There are four general functions that an expert can perform in this regard: to establish the reliability of the scientific theories and techniques embodied in a class of sensors; to document that the particular device employed to obtain the submission was constructed and operated in a manner consistent with those scientific principles; to identify the submission as the sensing output originally produced or its lineal descendent; and to interpret the information in a way that makes it meaningful to the trier of fact.

2. *Reliability of remote sensing techniques.* Exclusionary rules are often based on a desire to withhold potentially untrustworthy evidence from the legal proceedings.⁸³ A number of criteria are used in assessing the reliability of evidence.

81. Much of the following is an expanded version of the preliminary analysis prepared by P. Uhler, *Remote Sensing Data as Legal Evidence: The Need to Establish Standards* (1989) (unpublished manuscript on file with author).

82. *Id.*; see also Gianelli, *The Admissibility of Novel Scientific Evidence: Frye v. U. S., a Half-Century Later*, 80 COLUM. L. REV. 1197 (1980); M. SAKS & R. VAN DUIZEND, *supra* note 39, at 4-10.

83. See FED. R. EVID. 801-806 (hearsay); FED. R. EVID. 801 (definitions). Rule 801 (Definitions).

The following definitions apply under this article:

(a) Statement,

A "statement" is . . . (2) non-verbal conduct . . . if . . . intended as an assertion.

The Notes of Advisory Committee on Proposed Rules, accompanying FED. R. EVID. 801, state "When evidence of conduct is offered on the theory that it is not a statement, and hence not hearsay, a preliminary determination will be required to determine whether an assertion is intended."

(a) Acceptance in the scientific community.⁸⁴ The single most important factor that courts have considered in determining the reliability of a scientific technique is the extent to which that technique is accepted within the relevant professional disciplines. A principal requirement is for the scientific technique to have passed from the experimental to the demonstrable or operational stage. This is especially troublesome in an era when most remote sensing systems are experimental.

The relevant standard for admission of novel scientific evidence was set out in *Frye v. United States*.⁸⁵ *Frye* established a "general acceptance in the scientific community" test for admissibility and most courts have applied the *Frye* test to novel scientific evidence for approximately fifty years.⁸⁶ Critics of the *Frye* standard argue that it is too inflexible because rigid application of it requires courts to wait until the new technique has been "generally accepted" in the scientific community. In addition, critics note that the *Frye* standard has been rejected by many modern evidence codes.⁸⁷ For these and other reasons, many courts have abandoned *Frye* in favor of a "relevancy standard," guided by the applicable rules of evidence.⁸⁸ Those courts generally hold that when a scientific test has no established track record in litigation, trial courts should look to a variety of factors bearing upon the reliability of the test. These

Cf. FED. R. EVID. 803 (Hearsay exceptions; Availability of Declarant Immaterial).

(24) Other Exceptions:

A statement not specifically covered by any of the foregoing exceptions but having equivalent circumstantial guarantees of trustworthiness, if the court determines that (A) the statement is offered as evidence of a material fact; (B) the statement is more probative on the point for which it is offered than any other evidence which the proponent can procure through reasonable efforts; and (C) the general purposes of these rules and the interests of justice will best be served by admission of the statement into evidence. However, a statement may not be admitted under this exception unless the proponent of it makes known to the adverse party sufficiently in advance of the trial or hearing to provide the adverse party with a fair opportunity to prepare to meet it, the proponent's intention to offer the statement and the particulars of it, including the name and address of the declarant.

84. See also note 29 and accompanying text.

85. 293 F. 1013 (D. C. Cir. 1923).

86. Olivas, *DNA: The Eyewitness of the Future*, 18 COLO. LAW. 1333 (1989) (citing Gianelli, *supra* note 82). A recent article noted that, "[u]nder the *Frye* standard, proponents have to show the technology has gained general acceptance. The Federal Rules of Evidence contain more precise requirements. Rules 901a, 401, 402, 403, 702, 703, and 705 can apply. These rules deal with issues of authenticity, relevancy, expert testimony and possible prejudicial or cumulative aspects of the evidence." Marcotte, *supra* note 100, at 55. "What lawyers have seen so far is only the beginning. New uses of the laser disk and lap top computers are nothing short of revolutionary, according to [an attorney interviewed for the article]. While lawyers have always been able to bring physical objects into court, 'this allows you to do something lawyers have only dreamed of — it is a way of bringing events into the courtroom,' [the same attorney noted]." *Id.* at 56.

87. *Id.* at 1335.

88. *Id.*

DISPUTE RESOLUTION IN THE SPACE AGE

factors include the novelty of the technique, its relationship to more established modes of scientific analysis, the existence of specialized literature dealing with the technique, the qualifications of the expert witnesses, and the nonjudicial uses of the scientific technique.⁸⁹ The courts often point to various versions of Federal Rule of Evidence 702, relating to admissibility of scientific, technical, or specialized testimony, as governing admissibility.⁹⁰ In alternative dispute forums, parties may simply agree to similar standards for admissibility by reference to such relevance and reliability standards; failing agreement, neutral experts could select standards.

An additional consideration is whether and to what extent admission of such information will unfairly prejudice or mislead the trier of fact. Ultimately, where a scientific procedure is unable to generate reliable results, it is not helpful to a trier of fact and should be excluded under the rules. Similarly, even if reliable, Federal (and comparable state) Rule 403 considerations may apply to admissibility.

(b) Assignability to a scientific discipline. In deciding whether to admit scientific evidence, courts have considered the degree to which the scientific principles involved may be assigned to a single or limited number of well-recognized scientific disciplines. However, with regard to global environmental research, the trend is to take an interdisciplinary "earth system science" perspective. Many sensors are being constructed with the objective of performing interdisciplinary measurement, further confusing the legal picture from this standpoint.

(c) Nonlegal uses of a technique. In some instances proof that a technique is extensively employed within the scientific community obviates the need for proof that the underlying scientific principles have achieved substantial professional acceptance. It should be emphasized that the important element here is reliance on a technique by the scientific community, not by law enforcement officials or the community at large.

(d) Subjective interpretation. Reliability may be further defined in terms of accuracy and repeatability. Accuracy is the ability to measure a phenomenon within a given tolerance level or margin of error; *repeatability* is the ability to produce consistent results (within a margin of error) when a process is applied to identical phenomena. The most prevalent and satisfactory method of demonstrating the validity of an environmental remote sensing application is to compare the interpreta-

89. See D. Beerbower, *supra* note 30; J. LAPIN & R. PATTERSON, *supra* note 30; J. Bowman, *supra* note 74.

90. See, e.g., *Andrews v. Florida*, 87-2166 (Fla. App. 5th Dist. 1988); *People v. Hampton*, 746 P. 2d 947 (Colo. 1987); *United States v. Downing*, 753 F. 2d 1224 (3d Cir. 1985).

tion of remote images with an analysis of samples obtained from the area depicted in the image, a process known as "ground truthing."

(e) Uncontrolled variables. In many remote sensing applications such environmental variables as sun angle, wind direction, precipitation, temperature, cloud cover, and background reflectance may significantly affect the appearance and reliability of sensor output. Ground-truthing may be essential to demonstrate that a remote sensor can produce repeatable results over the range of environmental conditions that might prevail when the images are actually collected.

3. *Proper conduct of the remote sensing process.* This analysis of the conduct of the sensing activity and techniques is directed not at whether the process *could* yield trustworthy results, but at whether the application of that process in a specific case *did* yield the desired degree of trustworthiness. There are three general lines of inquiry relevant to evaluating the proper conduct of remote sensing techniques: (1) whether the selected methods sufficiently parallel those encompassed in the approved model of the process, (2) whether the methods were properly applied in the particular instance, and (3) whether the process was conducted by qualified individuals. All three of these issues rely substantially on the existence of well-defined and established technical standards and procedures.⁹¹

4. *Authentication and proof of contents.*⁹² The quest for reliable evidence is at the heart of the legal requirement that a scientific process be proved valid and properly conducted in each specific instance. Assurance of reliability is equally basic to the requirement for authentication of demonstrative evidence, but authentication involves establishing the identity of a submission rather than the truth of its contents. For graphic representations, including photographs and remote sensing output, the authentication prerequisites may be addressed in terms of two essential issues: (1) whether the image actually depicts what it purports to depict, and (2) whether the image submitted in court is legally equivalent to that which was initially obtained.

In contrast to everyday practice, the law usually requires the identity of a submission to be proved by extrinsic facts and testimony rather than by an inspection of the contents or properties of the submission itself.

91. See H. Sheetz, *The Value of Creating Standards for Emerging Technologies* (1989) (unpublished manuscript); see also Charter of the American Institute of Aeronautics and Astronautics/Space-Based Observation Systems Committee on Standards [hereinafter AIAA/SBOS/COS]: "Adoption, modification, development and recommendation of standards, recommended practices and guidelines relating to satellite subsystems (space segment and ground segment) that study the earth and its environment in space." *Reprinted in* 1 ORBITER 1, 1 (Summer 1989).

92. FED. R. EVID. 901-903.

DISPUTE RESOLUTION IN THE SPACE AGE

The first step of an ideal authentication process, then, consists of testimony by a witness who personally observed the object used, the document written, or the scene portrayed. Thereafter, a complete chain of custody for the exhibit must be documented. That is, the evidence should be directly traceable from the moment it is released or assumes legal significance to the time of submission, and each custodian should be able to substantiate that the object, document, or image was preserved in an essentially unchanged condition during his possession.

The more remote sensing data is processed or enhanced from its "raw," primary state, the more difficult it is to authenticate or prove its contents. Enhancement techniques span a continuum that may be roughly divided into four categories: (1) methods that clarify rather than modify the visible contents of a photographic or reconstructed remote sensing image; (2) methods that emphasize features or relationships not apparent on the face of the original image, but do not significantly alter its contents; (3) methods that intentionally alter, suppress, or accentuate certain features in order to highlight conditions of particular interest to the investigator; and (4) purely computational methods whose output is statistical rather than graphic in nature. With the exception of the products in the first category, all pose serious characterization problems for the law. Not only do the technical processes obfuscate the method of derivation of the final product, but they defy accurate characterization within the existing rules of evidence.⁹³ This is one area in which changes in the law may be useful to accommodate the advances of a new technology.

B. Technical Standards and Protocols to Assure Admissibility - The DNA Fingerprinting Example

Because of the uncertainty about which standard may ultimately govern admissibility, novel forms of scientific evidence will continue to meet opposition based upon assertions that they are not generally accepted in

93. With DNA fingerprinting, there is no actual reproduction of an image of the original act which the evidence is introduced to establish. Yet this evidence is viewed by many as effectively equivalent to eyewitness testimony. On the other hand, remote sensing *can* provide data and imagery which actually constitutes, emulates, closely corroborates, or directly supports eyewitness evidence and is perhaps, in that sense, even more compelling than a DNA fingerprint. Furthermore, applications may be broader in civil and commercial conflicts where the burden of proof is substantially lower than the reasonable doubt criminal standard under which DNA fingerprinting has nevertheless proved useful. *See also* G. JOSEPH, MODERN VISUAL EVIDENCE § 2.02 (1987) (noting certain advantages of videotapes over live testimony). For a listing of various pros and cons regarding videotapes, see Sussman & Sussman, *Electronic Depositions*, 15 LITIGATION 26 (1989).

the relevant scientific field.⁹⁴ On the other hand, issues raised by the tension between irrelevancy and the general acceptance standard may, and perhaps should, address the weight rather than admissibility of such evidence.⁹⁵ In the case of DNA fingerprinting, concerns regarding admissibility tended to diminish when laboratories and those responsible for expert verification meticulously adhered to accepted protocols in the testing and differentiating processes.⁹⁶ Certainly where the issues at stake are not scrutinized under the more extreme criminal standard of "reasonable doubt" but rather under the lesser standard of "a preponderance of the evidence," there is a good chance that such information can be utilized to an extent commensurate with its value.

Although a maturing discipline, remote sensing imagery is still in an early stage of development.⁹⁷ Its attributes are in many respects directly derivative of common forms of visual demonstrative evidence, notably photographs and maps.⁹⁸ Indeed, the most common visual rendering of remotely sensed data has been as a photoimage made up of building blocks known as pixels or groundels, similar to the way in which a television image or photograph is made up of numerous grains, lines, or other compositional units. As commercial demand has increased in land use and cartographic applications, the format is more commonly an orthoimage, which is additionally rectified to enhance spatial accuracy. In a visual rendering, with minimal enhancement, information may be derived directly or with minimal expert manipulation, thus creating a powerful and persuasive type of demonstrative evidence.⁹⁹ At more sophisticated levels of enhancement the persuasive power rises, but so does the latitude for opposing arguments that the prejudicial effect of the evidence outweighs its technical and scientific credibility.¹⁰⁰ Foundation,

94. See *supra* note 85 and accompanying text (*Frye* case).

95. See Thompson & Ford, *DNA Typing: Acceptance and Weight of the New Genetic Identification Tests*, 75 VA. L. REV. 45 (1989).

96. The two most widely used testing labs, Cellmark and Lifecodes, follow written protocols for DNA testing. A third lab currently offers forensic DNA testing, Forensic Science Associates in Emeryville, California. As of March, 1989, Cellmark had testified 30 times in 17 states, including military cases (Cellmark Handout, "Court Cases in the United States"); Lifecodes had testified 53 times in 17 states (Lifecodes Handout, "Lifecodes Testimony"). See also Olivas, *supra* note 85, at 1334, 1336 (citing Beeler & Wiebe, *DNA Identification Tests and the Courts*, 63 WASH. L. REV. 903 (1988)). For an excellent summary of the DNA fingerprinting process, typical lab protocols, and technical limits thereof, see Burk, *DNA Fingerprinting: Possibilities and Pitfalls of a New Technique*, 78 JURIMETRICS J. 455 (1988).

97. See Kraselsky/D.O.C., *supra* note 3.

98. See Latin, *Remote Sensing Evidence and Environmental Law*, 64 CALIF. L. REV. 1300 (1976); P. Uhlir, *supra* note 81.

99. Kraselsky/D.O.C., *supra* note 3; P. Uhlir, *supra* note 81.

100. See Rocky Mountain News, June 27, 1989, at 18, col. 1. Rockwell/Dep't of Energy investigation of allegedly illegal disposal of hazardous wastes. Thermal infrared remote

chain of custody, and credibility issues may also arise with more sophisticated enhancement. At extreme levels of enhancement it could be suggested that the rendering is more the product of art than science, or at least universally accepted science. As remote sensing and its commercial applications continue to evolve, legal applications are also likely to increase. However, neither application nor private sector growth will be optimized unless providers and users insure that end products properly suit the anticipated application. Standards and admissibility protocols will be necessary.¹⁰¹

The forces at work which tend to delay the broader application of remote sensing data in the legal setting are essentially the same as for other settings: (1) the lack of lawyers with adequate education to readily embrace the use of novel remote sensing techniques and data products;¹⁰² (2) the absence of legal precedents for utilizing remote sensing information;¹⁰³ (3) the lack of technical standards, which undermines the credibility and effectiveness of the data; and (4) underdeveloped data management handling and distribution systems, which limit data availability.

sensing imagery had been used to establish probable cause to secure search warrants and seizure of records; Marcotte, *Animated Evidence, Delta 191, Crash Re-Created Through Computer Simulations at Trial*, 75 ABA J. 52 (Dec. 1989) (noting that with respect to laser disc storage, computer enhancements, and other tools used in the evidentiary simulation presentation, lawyers can face a host of objections to admissibility of computer animation. "Evidentiary issues include qualifying the computer-animation expert, the hardware and software used, input data and accuracy of the presentation." *Id.* at 55; Note, *Computer Simulations: How They Can Be Used at Trial and the Arguments for Admissibility*, 19 IND. L. REV. 735 (1986); G. JOSEPH, *supra* note 93.

101. *Cf. supra* text accompanying notes 93-95 (discussion of DNA fingerprinting technical protocols); note also that the SBOS/COS Communications and Data Systems Working Group's mission is "to define standards and guidelines for passive and active spaceborne sensors capable of detecting radiation in the range from high energy particles through microwave." And specifically to "tackle next the general subject of calibration [in order to help] the general industry in developing standard terms, methods and evaluation tools for one of the most significant scientific problem areas facing us as a large number of radiometric instruments are placed in orbit." 1 ORBITER 4, 5 (emphasis added).

102. One ABA committee is already at work trying to at least partially rectify this - the Section of Natural Resources, Energy and Environmental Law's Special Committee on Satellite Technology, of which the author is the founding chairman. Related work is also taking place in the ABA Real Property Section's Modernization of Land Records Committee of which B. Dansby, cited *supra* at note 14, is the present chair. The National Center for State Courts has also recently engaged the author to coordinate an education and demonstration program for state jurists as a pilot project to explore potential applications and developmental needs.

103. P. Uhler, *supra* note 81, at 2.

C. Fertile Categories for Evidentiary Applications of Remote Sensing

One class of remote sensing application involves the monitoring of natural environmental conditions and the impact of human actions upon them. When used to monitor water pollution, for example, remote sensing is employed as a cost-effective method to determine regional water quality and to detect specific contaminants, surface and sub-surface phenomena (such as currents and thermal layers) that influence the dispersion of effluents, and large-scale ecological degradation associated with water pollution. Similar techniques are in use or under development to accomplish analogous functions in connection with air quality and atmospheric conditions. Another type of application is intended to identify natural phenomena that may directly affect and imperil human activities.¹⁰⁴ Information on flood patterns and community susceptibility is another example.¹⁰⁵

For policy planning and management purposes, satellite sensing possesses two major advantages over conventional ground survey and aerial techniques: (1) the marginal cost of collecting information over a large geographical area is lower and (2) imaging of the ground on successive orbital passes allows resource managers and planners to monitor changes as they occur, and thus to identify developmental trends.¹⁰⁶ Investigatory applications may or may not be intended to produce direct evidence for use in litigation or other dispute processes. Instead, they may be designed to indicate where additional investigation is needed.¹⁰⁷ Examples of such applications include detection of concealed effluent discharge outlets, identification of air pollution sources, deterioration of vegetation,

104. See, e. g., Ives & Krebs, *Natural Hazards Research and Land-Use Planning Responses in Mountainous Terrain: The Town of Vail, Colorado Rocky Mountains*, U. S. A. 10 ARCTIC & ALPINE RES. 213 (1978). The project was part of a program sponsored by the NASA Office of University Affairs to apply remote sensing techniques and space technology to the solution of terrestrial problems.

105. See Biache, *Discussion of "changes detection,"* 1989 A.B.A.- A.S.P.R.S. WORKSHOP PROC.; see also P. Uhlir, *supra* note 81; Rocky Mountain News, *supra* note 100.

106. See P. Uhlir, *supra* note 81, at 2.

107. See J. Gootee, *Satellites and Remote Sensing: New Issues for the Natural Resources Lawyer* (March 20, 1987) (unpublished manuscript) (paper for presentation at the A.B.A. Special Committee on Satellite Technology Program regarding Dow Chemical Co. v. United States, 536 F. Supp. 1355 (E. D. Mi. 1982), *rev'd*, 749 F. 2d 307 (6th Cir. 1984), *aff'd*, 476 U.S. 227 (1986) (EPA's aerial photography of chemical company's 2000 acre industrial complex, although within the navigable air space, was a "search" for fourth amendment purposes. The open areas of the complex were more comparable to an open field than to "curtilage" of dwelling for purposes of aerial surveillance). *But see Dow*, 476 U.S. 227, 251 n.13 (Court suggests that if the surveillance was accomplished by using "satellite technology" or other equipment not available to the public the decision would have been different).

DISPUTE RESOLUTION IN THE SPACE AGE

undesirable mining practices, irrigation violations, ocean dumping, and identification of changes in land and water uses or development.¹⁰⁸

Although the technical standards and data management and distribution issues have been the focus of considerable attention by the scientific and operational remote sensing communities for some time, they have been all but ignored by the legal profession. However, the role of the legal community, soon to be all too apparent on both the national and international level, will be to translate the scientific results and environmental assessments into concrete governmental policies, and to participate in the adjudicative and enforcement processes. Those functions have been and will continue to be severely compromised, however, by inadequate data management, inadequate distribution structures, and poorly articulated technical standards. This will be the case not only in the environmental law area, but in all other legal applications of remote sensing information. Applications of remote sensing data to the legal process can be either narrowly focused, using information from one sensor at a specific time and place, or broadly based, employing a variety of data provided by many types of spacecraft. Legal applications may therefore be grouped according to three general categories: (1) applications aimed at the development of public policy, and especially at the creation of international agreements, legislation, or administrative regulations; (2) investigatory applications used in the monitoring of compliance with existing treaties, laws, and regulations; and (3) evidence admissible in litigation.

In addition to national security applications, where spacecraft derived data have been instrumental in developing objectives and negotiation strategies for arms control agreements over the past thirty years, civil governmental and commercial earth observation systems have collected important data and focused attention on regional and global environmental problems. In the national security arena, the 1963 Nuclear Test Ban Treaty and the 1972 SALT I and ABM Treaties are good examples. In civil governmental (science) applications, the understandings that we have today regarding the "greenhouse effect," stratospheric ozone depletion, deforestation, desertification, acid rain, and ocean pollution are excellent examples. The 1987 Convention for the Protection of the Ozone Layer was the first instance of an international environmental protection agreement founded largely on the basis of remote sensing information.¹⁰⁹ In addition to the indirect use of remote sensing for the purpose of developing information which will become admissible evidence, remote sensing data has been used as demonstrative evidence in litigation and in the

108. J. Gootee, *supra* note 107; H. Sheetz, *supra* note 91.

109. P. Uhler, *supra* note 81, at 2.

settling of claims. The National Environmental Satellite Data and Information Service (NESDIS) of the National Oceanic and Atmospheric Administration (NOAA), which operates the U.S. geostationary and polar-orbiting meteorological satellites, keeps some statistical information on requests for data according to user categories. During the 1987 and 1988 fiscal years, NESDIS received the following law-related requests for geostationary satellite data products:¹¹⁰

<u>User Category</u>	<u>No. of Requests</u>	<u>No. of Images</u>
Attorneys	79	1374
Insurance Adjustors	23	183
Transportation Companies	55	879
Consulting Meteorologists	382	2310

Similar records were unavailable for the polar-orbiting spacecraft, which in any event tend to be less useful as evidence of meteorological conditions for a specific time and place. This is because the geostationary satellites take repetitive measurements of the same area every twenty minutes, while the two polar orbiters each pass over any given location only twice per day. The low resolution (1-8 km.) of the data from the geostationary satellites, however, limits their evidentiary applications in legal proceedings. The images are useful for establishing meteorological conditions at the time that events or actions material to a dispute took place, but they are generally incapable of providing direct evidence of guilt or innocence. As sensor resolution increases, the capacity for collecting probative evidence becomes greater.¹¹¹ Notwithstanding the foregoing discussion however, fairly exhaustive searches of legal reference material, particularly federal and state court decisions regarding the use of LANDSAT and French SPOT data as evidence reveal only a handful of references.

There have been a few reports, however, from both EOSAT and SPOT Image, suggesting that a number of recent cases were resolved prior to trial as a direct result of satellite derived evidence. These settlements are confidential and thus not subject to verification at this time. Perhaps the most celebrated, and as yet unlitigated, environmental tort in history is the 1986 Chernobyl nuclear reactor disaster. The satellite coverage of that incident may point to what is in store for the future.

110. Interview with K. Metcalf of NESDIS by P. Uhler.

111. P. Uhler, *supra* note 81, at 6; see DEPT. OF COMMERCE, MARKETS FOR REMOTE SENSING SATELLITE DATA IN THE 1990s (1988) (Bruce S. Marks, principal contributor).

DISPUTE RESOLUTION IN THE SPACE AGE

Additional obstacles include those presented by legal issues regarding personal privacy, personal or corporate trade secrets, governmental secrets, and the "reasonable expectation of privacy" under the fourth amendment as well as first amendment issues pertaining to news media usage. To date, however, procedural rather than substantive barriers seem to provide the greater legal difficulty and the question of the mechanics of admissibility, discussed above, requires further illumination. The potential for utilizing remote sensing information both in litigation and in settling disputes is certain to increase as information resources multiply and attain higher levels of speed and sophistication. When used in conjunction with other sources, this unique information technology presents short-term and long-term opportunities for legal applications.

The planned deployment of many new Earth observation systems over the coming decade, together with the removal of some of the growth barriers, will significantly expand the opportunities for effective application of this technology in the legal setting.¹¹² The Appendix presents a current schedule of new Earth observation missions planned or approved for the upcoming decade together with the types of applications for the sensor systems to be carried on board. It is also reasonably likely that unforeseen applications of many of the sensors will evolve over time. Presumably, remote sensing information could be provided directly to a secure, neutral repository such as the courts or other public administrative institutions from either the civil or commercial remote sensing sectors if anticipated sensitivities in legal applications were high.¹¹³ Data from na-

112. See, e. g., *California v. Ciraolo*, 476 U.S. 207 (1986), *reh'g denied*, 478 U.S. 1014 (aerial photos used for drug prosecutions); *Dow Chemical Co. v. United States*, 476 U.S. 227, 251 n.13 (1986) (noting that satellite derived information would not necessarily alter a court's view of intrusiveness, nor expectations of privacy); but see *E. I. duPont deNemours & Co. v. Christopher* 431 F.2d 1012 (5th Cir. 1970), *cert. denied*, 400 U.S. 1024 (1971), *reh'g denied*, 401 U.S. 967 (wrongful appropriation of trade secrets via aerial photography of plant lay-out during construction phase); *Phillips Petroleum Co. v. Cowden*, 241 F.2d 586 (5th Cir. 1957); *Kennedy v. General Geophysical Co.*, 213 S.W. 2d 707 (Tex. Civ. App. 1948) (right of recovery for acquisition of information regarding mineral rights requires physical trespass, and only the trespass is actionable). Whether the use of *active* sensors, which penetrate physical structures or the ground via high-energy propagation, would constitute a physical trespass sufficient to find a right of recovery or support equitable relief is an open question.

113. The issue of establishing and maintaining a "truth" repository is a weighty one indeed. "The FBI [has set] up its own program of forensic DNA analysis . . . The agency . . . wants . . . to bring some degree of uniformity to DNA testing nationwide. This would facilitate the establishment of a DNA data bank and the comparison of DNA samples from persons and crime scenes in different jurisdictions." Marx, *supra* note 29, at 1616. Various states, including Colorado, have also begun exploring how to establish such programs for laboratories and data banks through their own states' bureaus of law enforcement investigation. See Olivas, *supra* note 86.

tional security systems might also be made available under certain limited conditions.

The commercial sector seeks to collect and distribute its information on a wide scale and places a variety of restrictions on the dissemination of that data, primarily by pricing structures which presumably reflect market forces. Consequently, commercial remote sensing data and its supporting technologies represent a commodity — that is, a private rather than a public “good.”

Substantial issues remain unresolved today regarding the extent to which civilian governmental operations and activities are in fact undercutting the growth of the commercial sector and its markets. Proposals have been put forth in several well regarded studies for rectifying this and other barriers and the present administration is reviewing those recommendations through its recently reconstituted National Space Council.¹¹⁴ Many other government and private agencies are also reviewing

Once DNA typing becomes widespread, data banks of DNA patterns will begin to accumulate. A good many questions remain about the operation of such data banks. One question concerns where to deposit the information. The FBI's National Crime Information Center is a possibility. Marx, *supra* note 29, at 1618.

“Members of the U. S. Armed Services and employees of the federal government are routinely fingerprinted, but DNA typing raises issues not raised by ordinary fingerprinting Fingerprints are used only for identification, but DNA contains additional information about parentage, for example, or genetic predisposition to disease.” Unless there are constraints upon its use one may not want to give up one's DNA. *Id.*

“Routine forensic use of DNA typing, is also likely . . . to change the nature of the defense in cases in which identity is an issue. A test that can identify a rape suspect with absolute certainty makes it hard for the suspect to argue that someone else committed the crime.” Interestingly again, some criminal law and procedure experts have noted that where DNA is introduced in criminal cases, “plea bargaining may become more common.” *Id.*

This author submits that plea bargaining is none other than the criminal procedure analog of ADR, the former is quite simply to the criminal process what the latter is to the civil process. In the case of the former, technological tools, even expensive ones, are usually embraced, once validated, as a means of supplanting advocacy and protracted process, even though the standard of proof is significantly higher. In the civil system, technological tools should therefore accelerate the acceptability of ADR methods as well, especially in view of the substantially lower burden of proof. The rate of that accelerated acceptance will probably depend upon resolution of political differences regarding the role of the courts as decision-making experts for civil disputes. In the case of purely commercial disputes, at least, that political resolution may ultimately turn upon the balance of prevailing views regarding the efficiency of judicial systems for effectively resolving commercial disputes in the face of those systems' cost and the question of who should actually bear that cost — taxpayers generally, or the commercial disputants themselves, who have apparently placed their money and resources at risk by having failed to resolve their conflicts via other available modes of business governance. See Lee, *supra* note 27; see also M. Galanter & J. Rogers, *supra* note 28.

114. For additional information regarding present and planned observational programs for global data acquisition, see SYSTEMS SCIENCES COMMITTEE, NASA ADVISORY COUNCIL, EARTH SYSTEMS SCIENCE: A CLOSER VIEW 1989-94 (1988).

DISPUTE RESOLUTION IN THE SPACE AGE

the same issues.¹¹⁵ Current studies generally conclude that if new technologies are to be commercialized successfully, they must overcome a set of economic, legal, and regulatory barriers. With respect to the legal barriers, blame is frequently assigned to legislative ignorance of issues, inadequate analytical resources to study issues, an adversarial legal process that impedes informal discussion, and the absence of a forum in which to air industrial concerns.¹¹⁶

VII. A CONFLICT MANAGEMENT AND DISPUTE RESOLUTION MODEL TAILORED FOR APPLICATION OF REMOTE SENSING INFORMATION AND NEUTRAL EXPERTISE - THE PACIFIC FISHERIES PROBLEM AS A POTENTIAL CASE STUDY

The Pacific Remote Sensing Alliance¹¹⁷ and several of its members have recently undertaken an assessment of historic data as a first step in a case study assessing how remote sensing satellite data might contribute to the control of illegal fishing operations in the North Pacific and Alaskan waters. It has preliminarily described how presently operating satellites and planned future systems might be so utilized and has proposed a demonstration program.

The problem to be studied consists of two types of illegal activity. The one receiving the most attention at the moment is the "drift net operations" in the open waters of the North Pacific. By deploying these large nets, competitors are arguably "strip mining" the ocean. There have been reports of between 700 to 1,500 vessels deploying over 30,000 miles of net each night.¹¹⁸ The second type of activity is occurring in the Gulf

115. See *supra* note 16.

116. Kraselsky/D.O.C., *supra* note 3.

117. The Pacific Remote Sensing Alliance is a nonprofit organization established to promote the commercialization of remote sensing, its application, and the interaction among individuals and organizations involved in Pacific Rim commercial activities using remote sensing data. The Alliance will advance this objective through study, promotion, education, and interaction among its members and other individuals involved.

118. Excerpted from letter from Mark H. Freeberg, representing the North Pacific Fishing Vessel Owners Association, Seattle, Washington, to Dr. E. A. Brown, President, Pacific Remote Sensing Alliance (Sept. 7, 1989), stating:

The west coast and Alaska fishing industry is extremely concerned about the illegal harvest of fish in the North Pacific Ocean. This concern emerges [due to documented information verifying] that foreign nations have been illegally harvesting and processing United States or United States-origin fish outside of agreed upon protocols. The illegal harvest spawns difficult biological, economic and political problems. The illegal harvests have been documented within the U. S. Exclusive Economic Zone (EEZ) in the Bering Sea and large amounts of U. S. origin salmon have been intercepted by foreign squid gill net boats, fishing outside of internationally agreed upon fishing zones. There have been estimates that at least 22 million

of Alaska and the Bering Sea, where foreign vessels intrude into the U.S. Exclusive Economic Zone.¹¹⁹

Control and enforcement differs significantly in the two cases. In the latter case, the illegal action is within U.S. territorial waters, hence U.S. law applies. In the case of drift net operations, however, the activity is on the high seas where international or treaty law may apply exclusively. In both cases, the critical steps in enforcement consist of locating and identifying illegally operating vessels and procuring conclusive evidence to support appropriate sanctions. Ultimately both problems may evolve into issue categories such as "poaching" upon public or privately owned resources or anticompetitive domestic business or foreign trade practices, possibly actionable under state, federal, or even international law. If such activities continue unabated, they may threaten prudent fishing practices by depleting fish and food chain stocks, traditionally considered to be "renewable" natural resources. As a conservation and industrial regulatory matter, a means for controlling harvesting becomes increasingly imperative as national and international competitive pressures mount and lead to conflicts over an adequate allocation scheme. In this sense, an industry-wide need is emerging for effective, publicly supported regulation. Until such regulation is in place, selective enforcement or other effective controls are required.¹²⁰

If feasible, industry members could use airborne and satellite systems to keep tabs on unfair competitive practices, supplementing relatively scarce public resources. This concept approaches the Business Disputing Group's¹²¹ notion of private enterprise enlisting public sanctioning processes for maintenance of an appropriate competitive balance across a particular industry or sector,¹²² but would expand it with the addition of private sector supplemental support.

Two types of satellite systems have the potential to contribute to the detection of anticompetitive practices. The first are the remote sensing imaging satellites. These systems passively collect images of the earth and relay them to the ground for processing (certain sensor systems "actively see" using radar, microwave, or similar transmitted and absorbed

pounds of illegally caught salmon (approximately 7 million individual fish) were being marketed in 1988.

119. *Id.*

120. Report by E. A. Brown, President, Pacific Remote Sensing Alliance, April 17, 1989 [hereinafter Brown Report] (unpublished manuscript on file with author).

121. M. Galanter & J. Rogers, *supra* note 28, state "Firms regulate themselves indirectly through strategic invocation of state power. They force issues of legal interpretation and implementation, lobby for government action, or in other ways influence the exercise of state authority over commercial dealings."

122. Brown Report, *supra* note 120; see also GEOSTAR, INC. 1989 ANNUAL REPORT (discussing present civil and commercial sector capabilities).

DISPUTE RESOLUTION IN THE SPACE AGE

or reflected energy). These satellites have the potential to "see" ships as well as to identify promising fishing waters, particularly when used with nonimaging sensors. The second type of system is one that tracks ships via interactive signal devices. This system can determine ship location and movement by electronically interrogating a ship-board transponder from a satellite and then relaying the information to a ground station. The concept is similar to that used in tracking aircraft near an airport. The use of satellites for ship location and tracking makes it possible to cover very large areas effectively, hence it is attractive for the fisheries problem.

The final determination of illegal operation may require direct visual or physical contact by aircraft or shipboard personnel, but the systematic application of satellite derived data should make more effective use of the limited number of ships and aircraft. With sufficiently sophisticated equipment and techniques it may even be possible to produce direct evidence of illegal activity, including the amount of any ill-gotten haul.

Members of the Pacific Remote Sensing Alliance have been studying this problem for about six months. One scenario that seems sound is as follows: surveillance satellites are used to provide near real time coverage to locate all shipping within the area of interest. Techniques that have been used to identify promising fishing areas can be used to help localize the search areas. All ships legally engaged in the area will carry a transponder for identification and tracking. All ships located by the surveillance system not carrying a transponder can then be identified and perhaps apprehended. This may, of course, be an over simplification given the electronic countermeasures used by illegal drug traffickers to camouflage aircraft involved in drug smuggling, a technique equally available to illegal fishing operators.

Illegal smuggling operations and fish poaching present a similar problem due to the vast areas of operation. The use of satellite systems to cover these very large areas is a natural application of the available "white" space technologies.¹²³ Where the need is sufficient and consistent with national security considerations, some of these methods might even be beneficially supported by selectively using "black" assets as well.¹²⁴

The above discussion suggests three ways that space systems may be able to help control illegal fishing operations:

1. Imaging satellite data in conjunction with related nonimaging data can identify promising fishing areas by observing the sea surface conditions. Several NASA studies have shown that satellite determined sea

123. See generally W. BURROWS, *DEEP BLACK: SPACE ESPIONAGE AND NATIONAL SECURITY* ch. 3 (1987).

124. See *id.* at 53.

surface temperature, ocean color, and processed spectral signatures can be helpful in locating promising fishing areas.¹²⁵ The Alliance has been informed that the Japanese use weather satellite data for fish location on a regular basis.¹²⁶ This technique is seldom used by the U.S. fishing industry. The use of this technology could pinpoint the most likely areas to search—those in which good but also illegal fishing operations may be expected. Such systems also have the potential to improve the industry's productivity in finding and harvesting fish.

2. Although there are a number of imaging satellites capable of showing ships, they are not presently suitable for operational locating and tracking. The relatively high resolution satellites from which these images are obtained normally have a two-week revisit time, due to their orbital parameters. On the other hand, the NOAA polar orbiting weather satellites typically fly over a given area several times a day. Although their resolution is one km., there are documented examples of "seeing" ship tracks. The physics of "seeing" even a one hundred meter ship with a one km. resolution instrument is not yet sufficiently understood,¹²⁷ nor is the satellite's reliability for operational sighting yet clear. The other limitation of these systems is the fact that their visible and infrared sensors cannot penetrate the extensive cloud cover frequently experienced over much of the potential "target" areas. To date, there is neither a systematic assessment of these satellites' value to the fisheries problem nor any criteria by which to assess their capabilities and limitations.

3. The third application of space systems to help control illegal fishing is the use of Radio Determination Satellite Service technology to locate a vessel and identify it by interrogating its on-board transponder. This technology has just entered the commercial exploitation phase. Current systems on the market possess limited message capability due to their band width and frequency allocations. A somewhat more restricted service is also available for ships. Typical operations establish ship communication via the transponder to a satellite in geostationary orbit.¹²⁸ The data is relayed to a ground station for processing and storage. The end user, for example a fishing fleet operator, receives the data via an electronic mail system which can be privately secured. With vessels so equipped and a satellite surveillance system in place, an enforcement agency can sort out legitimate operations from illegitimate operations. In addition, fleet operators can use the same combined systems to obtain

125. Brown Report, *supra* note 120.

126. Freeburg letter, *supra* note 118.

127. Brown Report, *supra* note 120.

128. See GEOSTAR, INC. 1989 ANNUAL REPORT, *supra* note 122.

DISPUTE RESOLUTION IN THE SPACE AGE

timely information regarding fish locations, weather and sea conditions, and company or competitor activities. This multiuser full-time activity would also enhance the economic efficiency of the system.

There are three U.S. civil satellite systems that provide image data suitable for such "operational" use. Two are weather satellites operated by NOAA. The GOES system satellites are in geostationary orbit and thus provide near continuous coverage over their viewing area. Data is available as WEFAX (Weather Facsimile) and VISSR (Visible and Infrared Spin Scan Radiometer data.) The VISSR data is useful in providing cloud cover and cloud/sea surface temperature information. The use of visible and infrared sensors provide day and night coverage. The resolution is generally greater than ten km. but is degraded by the poor viewing angle in the higher latitudes of the North Pacific and Alaskan waters. This data is suitable for defining gross weather features and sea surface conditions. As such it may be useful for identifying promising fishing areas, but not for determining ship location.

The second system, also operated by NOAA, is the polar orbiting weather satellites, known as TIROS-N (Television and Infrared Observation Satellite). The fourth of the TIROS-N satellites (NOAA-11) was launched in September 1989. It joins NOAA-10 which was launched in 1986. Using modest resolution and a wide ground swath, they cover the northern latitudes about ten times per day. The imaging system known as Advanced Very High Resolution Radiometer (AVHRR) provides two data sets. The first, Automatic Picture Transmission, sends low (about four km.) resolution data in two bands, one visible and one in the infrared. The second data set is High Resolution Picture Transmission (HRPT). HRPT uses five bands, one in the visible and four in the infrared. Its resolution is 1.1 km and is by far the most useful system now available for the fisheries problem. Because ground stations cost from \$100,000 to over \$1 million, there are few such stations. NOAA operates two Command and Data Acquisition stations, to receive both recorded and direct readout data. A third ground station receives direct readout data with limited attributes. These data are archived and can be obtained from the NOAA Satellite Data Service Division. Because there are no restrictions on the receipt of the down linked data, anyone may acquire it. However, there is no known catalog of that data.

The third system is LANDSAT which is operated by the Earth Observation Satellite Company. (EOSAT). EOSAT has an agreement with the Department of Commerce to sell data from this system. LANDSAT is a polar orbiting satellite, but the high resolution instruments it uses provide coverage only once every fourteen days. In addition, LANDSAT's instruments have been set for receiving data only over land so its data may not be helpful for obtaining water information. For the ship

tracking problem, LANDSAT's principle limitation is the infrequent repeat coverage of coastal areas and very limited data collection over open waters. Until the recent deployment of the TDRS data relay satellite, LANDSAT data was only received when a ground station was within line of sight of the satellite - up to a 1,500 mile radius from the ground station. With the deployment of the second TDRS satellite earlier this year, EOSAT can provide nearly global coverage.

In addition to the NOAA weather satellites, the U.S. Air Force has a two satellite constellation known as the Defense Meteorological Satellite Program (DMSP). These satellites have a series of special sensors to measure various atmospheric properties. Data from these satellites is encrypted so it is not generally available outside the military. However, after archiving and an enforced nondissemination period of about forty-five to sixty days the data is available in photo-reproduction formats through NOAA. This situation suggests a potential opportunity for gaining increased access to Department of Defense (DOD) system data, subject to appropriate national security review and oversight. In the emerging climate of DOD budget containment, such an opportunity may even provide an inducement for joint civil-DOD projects with shared funding.

The other spacefaring nations of the world have various weather and/or earth resource satellites, for example, the French earth resource system (SPOT)¹²⁹ and the Japanese J-ERS-1. The former is similar to LANDSAT except it has different spectral bands. It also provides panchromatic stereo pairs with a ten meter resolution. The ten meter resolution data has found favor with land use planners, and when coupled with stereo capability makes possible topographic maps from satellite data. SPOT Image (the U.S. marketing arm) has been particularly successful in marketing their product in the U.S.

Future satellite systems anticipate extensive use of radar, lidar,¹³⁰ and other active and more highly pervasive sensors. Three radar satellite systems are under development. The European Space Agency has a scheduled launch of European Earth Resource Satellite - 1 (E-ERS-1) next year. This system is important because it will be the first operational earth resource satellite with synthetic aperture radar (SAR) capability. SAR technology provides essentially all weather capability, so it has the potential to deal with the extensive cloud cover over the Alaskan waters. The University of Alaska at Fairbanks has been funded by NASA to be the U.S. ground receiving station for scientific uses of this data. The University of Alaska Geophysical Institute, which will operate the

129. Systems Probatoire d' Observation de la Terre. SPOT Image is a wholly owned subsidiary of CNES, the French Space Agency (Centre National de' Etudes Spatiales).

130. Laser determination radar; *see* Appendix.

DISPUTE RESOLUTION IN THE SPACE AGE

NASA ground station, will provide support to the scientific community, but has no plans to provide data for operational activities such as ship tracking. The J-ERS-1 (Japanese) system is to be launched in early 1992. The main object of this system is to provide Japan with a synthetic aperture radar with optical sensors for use in all weather conditions. This system will monitor the global environment and its natural resources, including agricultural crops, forests, and fish populations. To date, Japan has only agreed to provide the U.S. with limited data covering the area around the Fairbanks ground station. Finally, Canada has RADARSAT under development with a planned launch in 1994. All three satellites will have suitable resolution for ship tracking. The E-ERS-1 SAR will have thirty meter resolution; however, current plans do not contemplate operating this sensor over water. The J-ERS-1 SAR will have eighteen meter resolution and the RADARSAT ten meter resolution. It should also be noted that the USSR, China, India, Brazil, and Israel all have plans for deploying operational imaging satellites.

Although the U.S. has had both radar and ocean color sensor systems in the past, there is no current commitment to develop and fly satellite systems with these sensors. NASA does, however, plan to fly Shuttle sortie missions with the Shuttle Imaging Radar. SEASAT-1, an oceanographic satellite flew 106 days in 1978. Among other instruments, it carried a SAR with twenty-five meter resolution. The last of the NIMBUS research satellites launched by NASA in 1978 carried a Coastal Zone Color Scanner. This sensor had 0.8 km. resolution covering six bands designed to measure ocean surface temperature, chlorophyll, and surface vegetation. Data from this sensor, when combined or compared with AVHRR data, has been used to correlate sea surface color and temperature with tuna catches off the coast of California. The success of this system led to the development of the Airborne Ocean Color Imager which flies on a NASA aircraft. A new ocean color sensor was studied for possible deployment on the next LANDSAT satellite (LANDSAT 6 currently under construction). However, this plan was not implemented, and there is no current plan for development and launch of such an instrument.

In summary, there are a number of remote sensing satellite data sources now available but not yet utilized for the type of problem described. New systems with additional capabilities will become operational over the next several years but they may be developed without broader applications in mind unless wider segments of society begin to contribute to the planning dialogue, as is now happening in the fisheries example. Present data is not being used to detect illegal fishing operations in the North Pacific or Alaskan waters but perhaps could be, even though currently operational satellites are far from ideal for this pur-

pose. In any event there appears to be no systematic assessment of these systems for the fisheries or similar types of problems. Several studies have, however, suggested that useful information can be obtained under certain conditions¹³¹ although it remains to be seen whether such information can effectively support enforcement or related operational applications.¹³² An evaluation of historic data has been undertaken by the Pacific Remote Sensing Alliance with support from several of its mem-

131. Brown Report, *supra* note 120.

132. As with DNA, certain attributes of satellite remote sensing technology are rapidly finding their way into numerous evolutionary applications. For example, "sophisticated image-enhancement techniques developed by the National Aeronautics and Space Administration to study the surfaces of distant planets" are being used to render visible, writing which had deteriorated and faded on ancient parchments such as the Dead Sea Scrolls and then, more importantly, to preserve the enhanced text for study and analysis. Elmer-De-Witt, *When the Dead Are Revived*, TIME, March 14, 1988, at 80. This has been applied to the legendary "Genesis Apocryphon," the only one of the original Dead Sea Scrolls whose contents had remained largely unread. The scroll, containing a narrative version of the book of *Genesis* had deteriorated so badly that scholars despaired of ever uncovering its secrets. *Id.* At the time of that report, several startling and hitherto unknown passages were already being read using this technique. The processes relied upon, notably digitization and pixelization, proved so effective that it prompted the team leader to note that in the future, digitization will probably be carried out at the site of the archeological find because, with this powerful evidence gathering capability, "we should treat documents like a murdered body. Leave it where it lies until the evidence can be collected from it." *Id.* at 81. But more visionary perhaps than the recognition by archeologists that technological evidentiary tools can provide clearer insights into past occurrences or records, is the even greater promise for the future, when such technology is combined with the higher speed and more accurate decisional systems, still essentially the province of the social sciences. The vision inevitably carries one to a recognition that in fact, as we enter more deeply into an age when humans work and live in space that, "Astrolaw commentators seem united in support of the proposition that the adversarial system of dispute resolution will not only fail in space but, if followed, endanger the lives of spacefarers on missions of long duration." See Glazer, *Astrolaw Jurisprudence in Space as a Place: Right Reason for the Right Stuff*, 11 BROOKLYN J. INT'L L. 1, 15 (1985); Note, *Dispute Resolution in Space*, 7 HASTING INT'L & COMP. L. REV. 211 (1983); See also Costello, *Space Dwelling Families: The Projected Application of Family Law in Artificial Living Environments*, 15 SETON HALL L. REV. 11 (1984). Cf. Robbins, *The Extension of United States Criminal Jurisdiction to Outer Space*, 23 SANTA CLARA L. REV. 627 (1983). In harnessing the skills of law schools and business schools within the Enterprise to explore, as a contractual requirement of the Enterprise binding upon all Members, an array of nonadversarial techniques for dispute resolution, clues to a new, and a needed, jurisprudence for space may emerge. As candidly stated in one newspaper editorial:

If Astrolaw can raise out-of-court resolution to the *level of art*, that achievement could more than pay for a space station. Then perhaps we could borrow the techniques to cut down the lengthy litigation that has tied us up in knots down here on the edge of the wilderness.

Santa Barbara Newspress, Feb. 29, 1984, at F10, col. 1 (emphasis added). The foregoing is excerpted from Glazer, *The Expanded Use of Space Act Authority to Accelerate Space Commercialization Through Advanced Joint Enterprises Between Federal and Non-federal Constituencies*, 12 RUTGERS COMP. & TECH. L.J. 339, 386 n.151 (1987); see also Glazer, *Domicile and Industry in Outer Space*, 17 COLUM. J. TRANSNAT'L L. 1, 67-117 (1978).

DISPUTE RESOLUTION IN THE SPACE AGE

bers. If the initial study shows promise, a more aggressive program will be proposed and funding will be solicited to support the effort.

As with the evaluation and refinement of DNA science and its subsequent unexpected application as a "fingerprinting" tool, remote sensing technology, particularly in combination with advanced generation computing, may present a revolutionary opportunity for advancing social science through highly improved dispute resolution and conflict management methods.

VIII. CONCLUSION

Specialized expertise is essential for the successful application of remote sensing to legal or nonlegal tasks, such as in the fisheries example discussed in the preceding section. In addition, remote sensing technology as a tool for dispute resolution or conflict management requires repeatable reliability in order to establish its credibility. The DNA fingerprinting standardization process has begun to prove its utility as a sufficiently reliable form of scientific evidence in courts, notwithstanding the rigorous scrutiny to which it has been subjected. Likewise, satellite and airborne remote sensing is rapidly becoming a reliable, useful information technology. Whether it will become widely recognized as reliable for evidentiary uses will depend upon its particular application and the degree to which it is refined for such a purpose. At the same time, the technology must become more market driven in order to develop it for those purposes. Therefore, more aggressive efforts to utilize it in appropriate situations may help to advance the interests of both users and providers. The refining process depends upon its potential utility, but its utility depends upon how innovative market uses drive its development. By using DNA fingerprinting as an illustration of how a technological tool can be usefully applied in legal proceedings, this Article has tried to illustrate how remote sensing could be used to settle disputes, thus encouraging market forces to drive its development. Balanced experimentation combined with rigorous, structured scrutiny are likely to yield both the best and the fastest results.

The question presented now is whether and to what extent public or private support should be directed towards harnessing this hard science tool to serve the arguably lagging soft science systems which presently comprise the social ordering and engineering enterprises of public administration and private management. It must be left for subsequent study to empirically assess the overall societal value of DNA fingerprinting. If, on balance, its value is positive then one may surmise that the sooner it had been perfected and harnessed the greater would have been its long-term benefit. Similarly, more rapid development of operational remote

sensing, as a reliable information and evidentiary tool also has substantial appeal, notwithstanding the obstacles and issues which will undoubtedly arise during the course of its development. The interdisciplinary nature of the dialogue spawned by the alternative dispute resolution movement, along with operational application of its methods, promises to become a major catalyst for early harnessing of such technologically advanced tools.

Appendix I

Part 1

OBSERVATIONAL PROGRAMS FOR GLOBAL DATA ACQUISITION

Part 1: Representative Examples of Approved and Continuing Programs

Representative Space Programs

Program	Agency/ Status	Objectives
POES: Polar-orbiting Operational Environmental Satellite	NOAA/Operating	Meteorological observations; measurements of sea-surface temperature, sea ice, and snow cover; assessment of condition of vegetation
GOES: Geostationary Operational Environmental Satellite	NOAA/Operating	Operational weather data, cloud cover, temperature profiles, real-time storm monitoring, severe-storm warning, sea-surface temperature
DMSP: Defense Meteorological Satellite Program	DoD/Operating	Weather observations for Department of Defense
METEOSAT: Meteorology Satellite	ESA/Operating	Operational weather data, cloud cover, water-vapor imagery
Nimbus-7	NASA/Operating	Monitoring of atmospheric pollutants, ocean chlorophyll concentrations, weather, climate
GMS: Geostationary Meteorological Satellite	NASDA (Japan)/Operating	Operational weather data, cloud cover, temperature profiles, real-time storm monitoring, severe-storm warning
METEOR: Meteorological Satellite	USSR/Operating	Meteorological observations, sea-surface temperature, sea ice, snow cover, vegetation condition

*Adapted from *Earth System Science: A Closer View*, Earth System Sciences Committee, NASA Advisory Council, NASA, pp. 189-94, (1988).

DISPUTE RESOLUTION IN THE SPACE AGE

INSAT: Indian National Satellite	India/Operating	Meteorology domestic communications, television program distribution
ERBS: Earth Radiation Budget Satellite	NASA-NOAA/Operating	Observations of Earth radiation budget
LANDSAT: Land Remote-sensing Satellite	EOSAT/Operating	Operational and commercial data, land-use inventory, geological and mineralogical exploration, crop and forestry assessment, cartography
SPOT: Systeme pour l'Observation de la Terre	France/Operating	Operational data on land use and inventory
LAGEOS-I: Laser Geodynamics Satellite-I	NASA/Operating	Geodynamics, gravity field
GEOSAT: Geodesy Satellite	DoD/Operating	Geodesy, shape of the geoid, ocean and atmospheric properties
MOS-I: Marine Observation Satellite-I	NASDA (Japan)/Operating	State of sea surface and atmosphere
GPS: Global Positioning System	DoD-NSF-NOAA-NASA-USGS/Completion 1990	Geodesy, crustal deformation
IRS: Indian Remote-sensing Satellite	India/Launch 1987	Agricultural, hydrological and geological data for natural-resource management
Space Shuttle program—representative U.S. instruments:		
• ATMOS: Atmospheric Trace Molecules Observed by Spectroscopy	NASA/Current	Atmospheric chemical composition
• ACR: Active Cavity Radiometer	NASA/Current	Solar energy output
• SUSIM Solar Ultraviolet Spectral Irradiance Monitor	NASA/Current	Ultraviolet solar observations
• Hand-held Camera	NASA/Current	Exploratory observations of meteorological, oceanographic, biological, and geological processes
• Lagre Format Camera	NASA/Current	Detailed studies of land-surface features
• LIDAR: Light Detection and Ranging Instrument	NASA/Planned	Surface topography atmospheric properties
ERS-1 ESA Remote-sensing Satellite-I	ESA/Launch 1989	All-weather imagery of oceans, coastal waters, ice fields, and land areas
UARS: Upper Atmosphere Research Satellite	NASA/Launch 1991	Coordinated measurement of upper-atmosphere parameters
JERS-1: Japanese Earth Remote-sensing Satellite-I	NASDA (Japan)/Launch 1991	Global exploration of mineral and energy resources, management of agricultural and forestry resources, environmental monitoring, land-use planning
TOPEX/Poseidon Ocean Topography Experiment	NASA-CNES (France)/Launch 1991	Ocean-surface topography, ocean-current signatures

Part 2: Representative Examples of Proposed Future Programs**Representative Space Programs**

Program	Agency/ Status	Objectives
MOS-2: Marine Observation Satellite-2	NASDA (Japan)/ Launch 1991	State of sea surface and atmosphere
RADARSAT: Radar Satellite	Canada/ Launch 1994	High-resolution studies of arctic area, agriculture forestry and water-resource management ocean studies
Individual instruments for long-term global observations:		
• Ocean color scanner	EOSAT/Planned	Ocean biological productivity
• Earth radiation budget instrument	NASA-NOAA/Planned	Earth radiation budget on synoptic and planetary scales
• Carbon-monoxide monitor	NASA/Planned	Monitor tropospheric carbon monoxide
• Total ozone monitor	NASA/Planned	Monitor global ozone
• Geodynamics laser ranging system	NASA/Planned	Crustal deformations over specific tectonic areas
• Scanning radar altimeter	NASA/Planned	Conocatal topography
Eos Earth Observation System	United States-other nations/ Launches 1995, 1996, 1997-98	For deployment scenario, instruments, and objectives, see Part 3
GREM: Geopotential Research Explorer Mission	NASA/Initiate 1989, launch 1991	Measure gravity and magnetic fields for tectonophysics, mantle convection, internal structure and composition, crustal magnetic anomalies main magnetic field
TREM: Tropical Rainfall Explorer Mission	NASA/Initiate 1991, launch 1993	Tropical precipitation measurements
European Polar-Orbiting Platform (Columbus)	ESA/Launch 1996	Long-term comprehensive research, operational and commercial Earth observations as part of Earth Observing System (see Part 3)

Part 3: EOS Instruments: Initial Operational Configuration (IOC)

Instruments in the Principal Investigator (P1) class, and advanced versions of other instruments, will be selected in response to Announcements of Opportunity by the United States (NASA), the European Space Agency (ESA), and Japan

Instrument	Source/ Platform	Objectives
ALT: Radar Altimeter	NOAA/1: ESA/3	Ocean circulation surface topography
AMIR: Advanced Microwave Imaging Radiometer	Europe/3	Snow and ice extent and character, sea-surface winds, atmospheric water vapor, surface temperature
AMRIR: Advanced Medium Resolution Imagery Radiometer ^d	NOAA/1.3	Surface temperature, snow and ice extent, cloud properties, atmospheric temperature and water content

DISPUTE RESOLUTION IN THE SPACE AGE

AMSR: Advanced Microwave Scanning Radiometer	Japan/1	Precipitation rate, snow and ice extent and character, sea-surface winds, atmospheric water vapor, surface temperature
AMSU: Advanced Microwave Sounding Unit ^d	NOAA-UK/1.3	Surface temperature, atmospheric water content, atmospheric temperature
ARGOS: French satellite-borne data relay and platform location system (advanced version) ^a	France/1.3	Data relay and location of ground-based measurement platforms
ATLID: Atmospheric Lidar	ESA/3	Aerosols and atmospheric parameters
ATSR: Along Track Scanning Radiometer	U.K.-Australia/3	Sea-surface temperature, atmospheric corrections
CR: Correlation Radiometer	PI/1	Tropospheric composition (carbon monoxide)
DB: Direct Broadcast	NOAA/1.2.3	Communications and data distribution
ERBI: Earth Radiation Budget Instrument	NOAA/1.3	Earth radiation budget on regional, zonal, and global scales
F/P-INT Fabry-Perot Interferometer	PI/2	Upper-atmosphere wind velocities
GLRS Geodynamics Laser Ranging System	NASA/3	Tectonic-plate motions, ice flow, altimetry, surface topography
GOMR: Global Ozone Monitoring Radiometer	NOAA/1	Total ozone column content and profile
HIRIS: High Resolution Imaging Spectrometer	NASA/1	Biological activity, land-surface composition
HRIS: High Resolution Imaging Spectrometer	EAS/3	Biological activity, land-surface composition
IR-RAD Infrared Radiometer	PI/2	Composition of upper atmosphere, aerosols
ITiR: Imaging Thermal infrared ¹	Japan/1	Surface temperature, surface composition, biological activity
MAG Magnetosphere Currents/Fields	PI/1.2.3	Measurements of magnetospheric currents and fields
MERIS: Medium Resolution Imaging Spectrometer ⁸	ESA/1	Ocean biological activity, land-surface composition and biological activity, total aerosol column content, cloud properties
MLS: Microwave Limb Sounder	PI/2	Upper-atmosphere composition and pressure
MODIS: Moderate-resolution imaging Spectrometer	NASA/1	Biological activity, land-surface composition, snow and ice extent, aerosols, cloud properties, surface temperature, atmospheric temperature profiles
MPD: Magnetospheric Particles Detectors	PI/1.3	Detection of magnetospheric particles
P/L-EX: Payload Executive	NASA/1.2	Optimization of instrument use, support of Direct Broadcast

PEM: Particle Environment Monitor	P1/2	Magnetospheric energy input into the atmosphere
PPS-PODS: Precise Position System-Precise Orbit Determination System	P1/1.3	Precise determinations of position and orbit
S&R: Search and Rescue	NOAA/1.3	Search and rescue operations
SAR: Synthetic Aperture Radar	NASA-FRG/2	Land-surface composition, topography, snow and ice extent and character, sea-ice extent and character, ocean waves, wetlands extent, soil moisture
SAR-C: Synthetic-Aperture Radar-C Band	ESA/3	Sea-ice extent and character, snow and ice extent and character, ocean waves, wetlands extent, soil moisture, topography, land-surface composition
SCATT: Scatterometer	NOAA/1-ESA/3	Sea-surface wind velocities
SEM: Space Environment Monitor	NOAA/1.3	Monitoring of particles and fields environment
SUB-MM: Submillimeter Spectrometer	P1/2	Composition of upper atmosphere
SUSIM: Solar Ultraviolet Spectral Irradiance Monitor	P1/2	Solar spectral irradiance

- (d) The AMRIR AMSU instrument pair supersedes the current AVHRR, HIRS operational instruments
- (e) The French ARGOS+ system supersedes the U.S. Advanced Data Collection and Location System
- (f) The Japanese ITIR instrument supersedes the U.S. Thermal Imaging Spectrometer (TIMS) instrument
- (g) The European Space Agency's MERIS instrument is essentially similar to and could replace the U.S. MODIS-Tilt instrument
- (h) The MODIS instrument listed here includes the MODIS-Nadir and MODIS-Tilt instruments

DISPUTE RESOLUTION IN THE SPACE AGE

Part 4: Earth Observation Missions (planned and approved) under consideration with the CEOS.

Mission	Objectives	Main Sensors	Orbit	Launch Date	Status of Approval
Brazil	Brazilian A-S Satellites	Land Applications	Multispectral Pushbroom Camera	650 KM alt Sun-synchr	Phase B In progress
Canada	Aedersal	Ice & Land Monitoring	• Synthetic Aperture Radar • Wind Scatterometer • Optical Sensor	1000 km alt. sun-synchr.	As above
ESA	ERS-1	Ocean-ice Monitoring	• Synthetic Aperture Radar • Wind & Wave Scatterometer • Radar Altimeter • ATSA • PRARE	780 km alt sun-synchr. 1989	Approved phase C/D to start in Dec. 1984
France	SPOT	Land Applications	High-Resolution Viable Instruments(x2)	832 km alt. sun-synchr.	SPOT-1 in 1985 SPOT-2 in 1987 Approved
	Poseidon	Ocean Circulation	• Radar Altimeter • Precise Positioning • Microwave Sounder	832 km alt. sun-synchr.	SPOT-3 in 1990 Phase B in progress
India	IRS-1	Land Applications	904 km alt.	1988 sun-synchr.	Approved
	MOS-1	Marine Applications	• MESSR • VTIA • MSA	909 km alt. sun-synchr.	1988 As above
Japan	J-ERS-1	Land Applications	• SAR • VNR	570 km alt. sun-synchr.	1990 As above
NASA	TOPEX	Ocean Circulation	• 2-Frequ. Radar altimeter • MW Radiom Precise Positioning	1300 km alt. 63° inclination	1980 Phase B in progress
NASA & Coop. with France	Topex/Poseidon	Ocean Circulation	As above + Poseidon Instr.	As above	As above
NOAA (+ NASA + NAVY)	NROSS	Oceanic Applications	• Radar Altimeter • Wind Scatterometer • Special Sensor MW Imager • Low Freq. MW Radiom	830 km alt. sun-synchr. 1989-90	As above
NOAA + private entity	Landsat 6 & 7	Land Applications	• Thematic Mapper • Multilinear Array	700 km alt. sun-synchr.	Landsat 6 in 1988 Landsat 7 in 1991 Under discussion in US Congress

